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Retention Basin Control

of

Combined Sewer Overflows

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27 Abstract The Springfield Sanitary District constructed a 10 acre basin to collect and detain combined sewer overflows that bypass ~~the Cook Street~~ pumping station during periods of high volume flows. Surface runoff accompanying rainstorms cause high volume flows which are diverted into the Cook ~~Street~~ channel. Such flows introduce highly toxic pollution loads into ~~Sugar~~ creek and ~~the South~~ fork of the Sangamon River. The retention basin was built to intercept these flows so that they could be stored temporarily and released at low flow rates ~~into Sugar Creek~~ to avoid shock pollution of the stream. Historically, the high concentrations of pollutants discharged into Sugar Creek have caused serious fishkill. The retention basin was designed to retain water to a depth of four feet before it discharges captured runoff through a spillway provided with a notched weir. Average annual reduction of BOD was 27 percent and coliform reduction averaged 72 percent. However during the period from June through October 1969, production of algae in the basin caused the effluent BOD to consistently exceed that of the influent. In addition to the oxygen demand ~~on the stream~~, production of algae may be objectionable at some installations for aesthetic reasons. Sludge accumulation ~~was significant in the basin and~~ must be taken into account in design of similar facilities. Suggestions for future designs of retention basins are included. (~~Poertner~~)
(WRSIC abstract)

—a—

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RETENTION BASIN CONTROL
OF COMBINED SEWER OVERFLOWS

by

Springfield Sanitary District
Springfield, Illinois

for the

ENVIRONMENTAL PROTECTION AGENCY
WATER QUALITY OFFICE

Grant 3-111-1

August, 1970

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ABSTRACT

Control of combined sewer overflows by retention in an open basin has been evaluated. Fish kills, which were numerous prior to construction of the facility, ceased and there was an increase in the abundance of pollution sensitive organisms in the stream below the basin.

Average annual reduction of BOD was 27 percent and coliform reduction averaged 72 percent. However during the period from June through October 1969, production of algae in the basin caused the effluent BOD to consistently exceed that of the influent. In addition to the oxygen demand on the stream, production of algae may be objectionable at some installations for aesthetic reasons. Sludge accumulation was significant in the basin and must be taken into account in design of similar facilities. Suggestions for future designs of retention basins are included.

The report was submitted in fulfillment of provisions of Demonstration Grant No. 3-111-1 between the Environmental Protection Agency, Water Quality Office and The Springfield Sanitary District.

Key Words: Combined sewers, urban drainage, retention basins, lagoons, combined sewer overflow.

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SECTION I

CONCLUSIONS AND RECOMMENDATIONS

A combined sewer overflow retention basin has been shown to be an effective means of limiting surface water quality deterioration at Springfield, Illinois following storms. Use of a constricted section in the basin overflow spillway limits the rate of flow to the stream during and immediately following a storm and retains excessive stormwater overflow for subsequent discharge at a diminished rate.

Best evidence of the efficacy of the facility is afforded by observation of the quality of the receiving stream, Sugar Creek. Fish kills, which occurred rather frequently prior to construction of the facility have occurred only once since the basin was completed, and this occurrence was while the basin was drained for repairs. In addition, a shift in the aquatic life in the stream from pollution tolerant to pollution sensitive has been observed.

Based on analysis of the concentration in daily composite samples, BOD reduction in the basin averaged 27 percent. However, during the sampling period June to October, 1969, the effluent BOD exceeded that of the influent due to algal production in the basin. In addition to the increased organic load on the receiving stream, the release of water with high algal density could cause aesthetic problems. Although coliform reduction in the basin averaged 72 percent, such basins alone could not be considered to provide adequate control of pathogenic organisms at all installations because high densities of indicator organisms still prevail in the basin discharge.

From the observations and data collected in evaluating the performance of the retention basin, the following conclusions and recommendations can be made:

1. Rational interpretation of the performance of the basin was limited by the lack of capability for controlling and measuring operational parameters. Any future retention basin demonstration projects should be equipped with provision for measuring the rate of flow into the basin and for collecting individual grab samples with high frequency from both the influent and effluent to permit assessment of fate of individual storm flows.

2. Appreciable accumulation of solids occurred in the basin. In the design of retention basins for combined sewer overflows, consideration must be given to the accumulation of sludge in the basin resulting from infrequent solids removal and disposal.

3. The practice of bypassing excess storm flows as was the required mode of operation in this study would seem to warrant further

consideration. If such provision is made in future basins, the design should allow for variation in the overflow level and for the ability to eliminate the bypass completely.

4. During periods of high stage in the receiving stream the basin did not function as intended. It would seem desirable in future basins to prevent river backup into the basin where possible by selection of a more appropriate basin site and by use of adjustable overflow weirs.

5. Multiple celled installations would seem to warrant consideration; further, the capabilities of future installations would be extended by making provision for either series or parallel operation.

SECTION II

INTRODUCTION

Nature of the Combined Sewer Problem

During an era when attitudes toward control of water pollution differed from those which prevail now, construction of combined sewers was common in the United States. The American Public Works Association has estimated that communities having a total population of 54 million are served in full or in part by combined sewers (1). The sewers convey in a single conduit both domestic and industrial wastes and urban runoff. When waste treatment was provided in communities with combined sewers it was impractical to provide enough interceptor and treatment plant capacity to accommodate the extremely high flows which occurred during rainfall. Hence, provision was made for overflow of combined sewers into receiving waters when total flow exceeded by several times the normal average dry weather flow. The apparent philosophy was that these overflows would tend to occur during periods of higher stream flow and would not seriously impair water quality.

In fact, serious water pollution problems have occurred as a result of overflow from combined sewers. While the problem has tended to be ignored in the past, population growth, increased industrialization, increased runoff factors from urban areas, and a greater concern for environmental quality have resulted in increased recognition of the problem in recent years. As an indication of this recognition, the Water Quality Act of 1965 contained special provisions for projects which might demonstrate new or improved methods of controlling discharges from combined sewers. The work considered in this report is such a project.

In earlier years, when attention was given to problems caused by combined sewer overflows, the tendency was to conclude that if combined sewers were a problem, then the solution of the problem was to construct separate sewers. The number of such separation projects carried out was large enough to provide cost information sufficient for the American Public Works Association to prepare an estimate of the total cost of separating combined sewers (1). They estimated that the total cost, including necessary plumbing changes on private property would be approximately $48 billion. The cost of such a program is by itself sufficient cause to explore alternative means of accomplishing the same objective. Further, there is reason to question the efficacy of a separation program. This is because the deterioration in water quality caused by combined sewer overflows is not solely attributable to its content of raw sewage. The urban drainage itself can be a significant source of common pollutional materials (2). Indeed, under the provisions of the Clean Water Restoration Act of 1966, projects for controlling pollution from storm water itself are eligible and it has been suggested that it may in the future become necessary to treat discharges from separate storm sewers prior to their release into receiving waters (2).

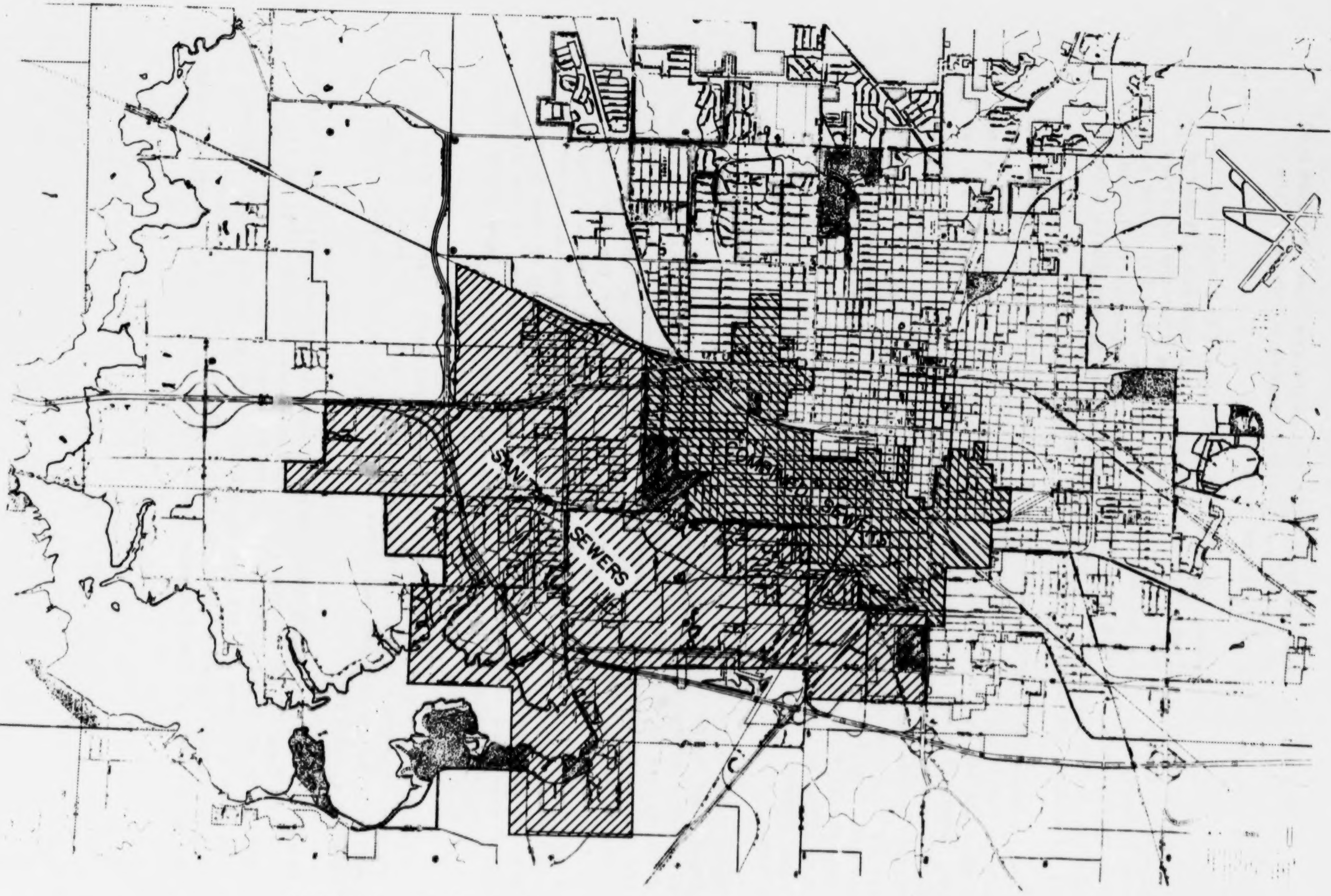
The program of the Storm and Combined Sewer Pollution Control Branch of the Federal Water Quality Administration has emphasized alternatives to storm water separation. Ideas for control of storm and combined sewer pollution prompted by the demonstration project program of FWQA have generally fallen into one of three categories (5). One approach emphasizes control of storm water flow through reduction of runoff, improved utilization of sewer systems, temporary storage, etc. Other projects emphasize treatment of wastes through chemical, biological and physical means. Finally, the third category of projects includes a combination of control and treatment. The project described in this report is of the latter type.

Nature of the Springfield Problem

Often the most severe water quality degradation from combined sewer overflows occurs from rather minor storms which are sufficient to overload combined sewers but insufficient to cause a high degree of dilution in the receiving watercourse (1). At Springfield, Illinois, these events occur with a greater than usual frequency because a combined sewer overflows to a small stream which has controlled discharge. The problem is created by combined sewers tributary to the Cook Street Pumping Station which overflow to a small stream, Sugar Creek, at a point downstream from Lake Springfield, an artificial reservoir in which flow is retained to meet the water supply needs of the city.

The history of nuisance conditions and water quality degradation resulting from the Cook Street Pumping Station overflow is a long one. During the 1960's, repeating instances of fish kills in Sugar Creek were attributed to the overflow and, indeed, damages for a fish kill were paid by the Springfield Sanitary District. A log of investigations of pollution of Sugar Creek by the Illinois State Sanitary Water Board and the Springfield Sanitary District is included as Appendix I, and data obtained during those investigations are presented in Appendix II.

The 3.45 sq mi of the drainage area tributary to the Cook Street Pumping Station is served by combined sewers. Figure 1 shows the area served by sanitary sewers as well as that having combined sewers, both of which contribute to the pumping station. The drainage area is almost completely urban in nature and the runoff coefficient has been estimated at 0.5 (4). Based on this area, runoff coefficient, and the rainfall intensity frequency data of Yarnell (5), stormflow to the pumping station has been estimated at 1,653 cfs for a 50-year storm and 1,873 cfs for a 100-year storm (4). For a 2-year storm (0.7 in./hr)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SEWERS
SEWERS

FIGURE 1. Drainage Area Tributary to Cook Street Pumping Station

runoff would be 771 cfs. Troemper (6) has estimated that the combined capacity of the 108 in. and 66 in. diameter sewers which serve the pumping station is 766 cfs without surcharge.

Four pumps with a combined capacity of 13,500 gpm (30.2 cfs) are installed at the Cook Street Pumping Station. This maximum discharge is about five times the average daily flow of sewage from the drainage area or about twice the maximum daily dry weather flow (7). The east side interceptor to which the pumping station discharges is loaded to capacity and an increase in capacity of the Cook Street Station could not eliminate the overflow of combined sewage (4).

Flow in excess of the capacity of the Cook Street Pumping Station is automatically bypassed to the Cook Street channel. Figures 2, 3, and 4 show the 66 in. and 108 in. diameter sewers discharging to the channel, downstream of pumping station. The Cook Street channel is a natural drainage course with intermittent flow. A stretch of the Cook Street Channel above the site of the retention basin is shown in Figure 5; note the dry weather flow. It is estimated that during storm periods, about 95 percent of the flow in the channel originates at the Cook Street Pumping Station. The combined sewer overflow travels about 9000 ft down the Cook Street channel where it is discharged to Sugar Creek. Figure 6 shows the location of the channel and Sugar Creek.

Sugar Creek is a small stream at the eastern edge of Springfield. About four miles above the confluence of the Cook Street drainage canal with Sugar Creek, the stream has been dammed to form Lake Springfield which serves as the raw water reservoir for the city. The function of the dam is to retain storm water discharges to supply water during periods of low stream flow. When adequate quantities of water are stored in the reservoir, excess flow is allowed to pass over the dam. However, during the critical summer months when stream flow is normally low, water temperatures are high, and equilibrium dissolved oxygen levels are comparatively low, virtually all water falling on the Sugar Creek watershed is retained in Lake Springfield. Hence, little dilution occurs and water quality degradation problems are especially critical during these times.

Backwash water from the Springfield water treatment plant and discharges from the City of Springfield power plant enter Sugar Creek immediately below the dam and above the point at which the Cook Street channel discharges.

Below the point at which the combined sewer overflow enters Sugar Creek from the Cook Street channel, the stream flows about 4 miles to its confluence with the South Fork of the Sangamon River. Instances of objectionable stream conditions have been confined to the short section of Sugar Creek between the Cook Street channel and its confluence with the South Fork of the Sangamon River. Because of the increased dilution

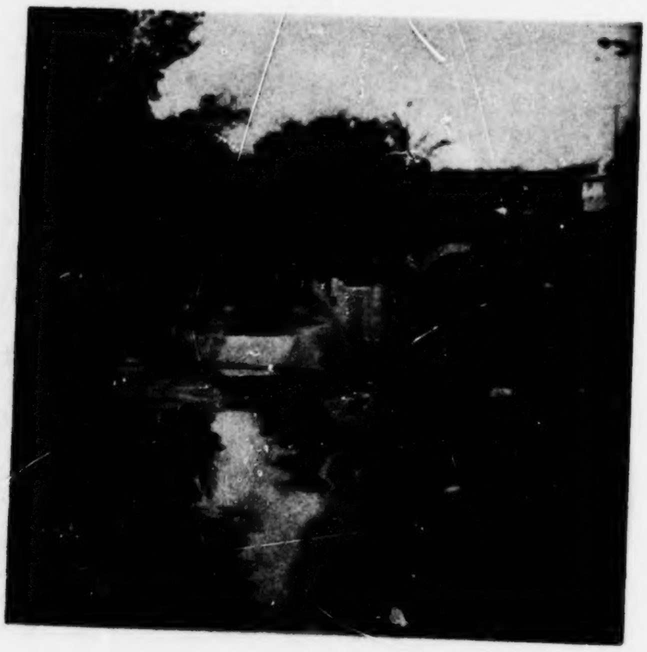

FIGURE 2. Overflow from Cook Street Pumping Station Discharging Channel through 66 in. and 108 in. Diameter Sewers

FIGURE 3. 66 in. Diameter Sewer Discharging to Cook Street Channel

FIGURE 4. 108 in. Diameter Sewer Discharging to Cook Street Channel

FIGURE 5. Cook Street Channel above Site of Retention Basin

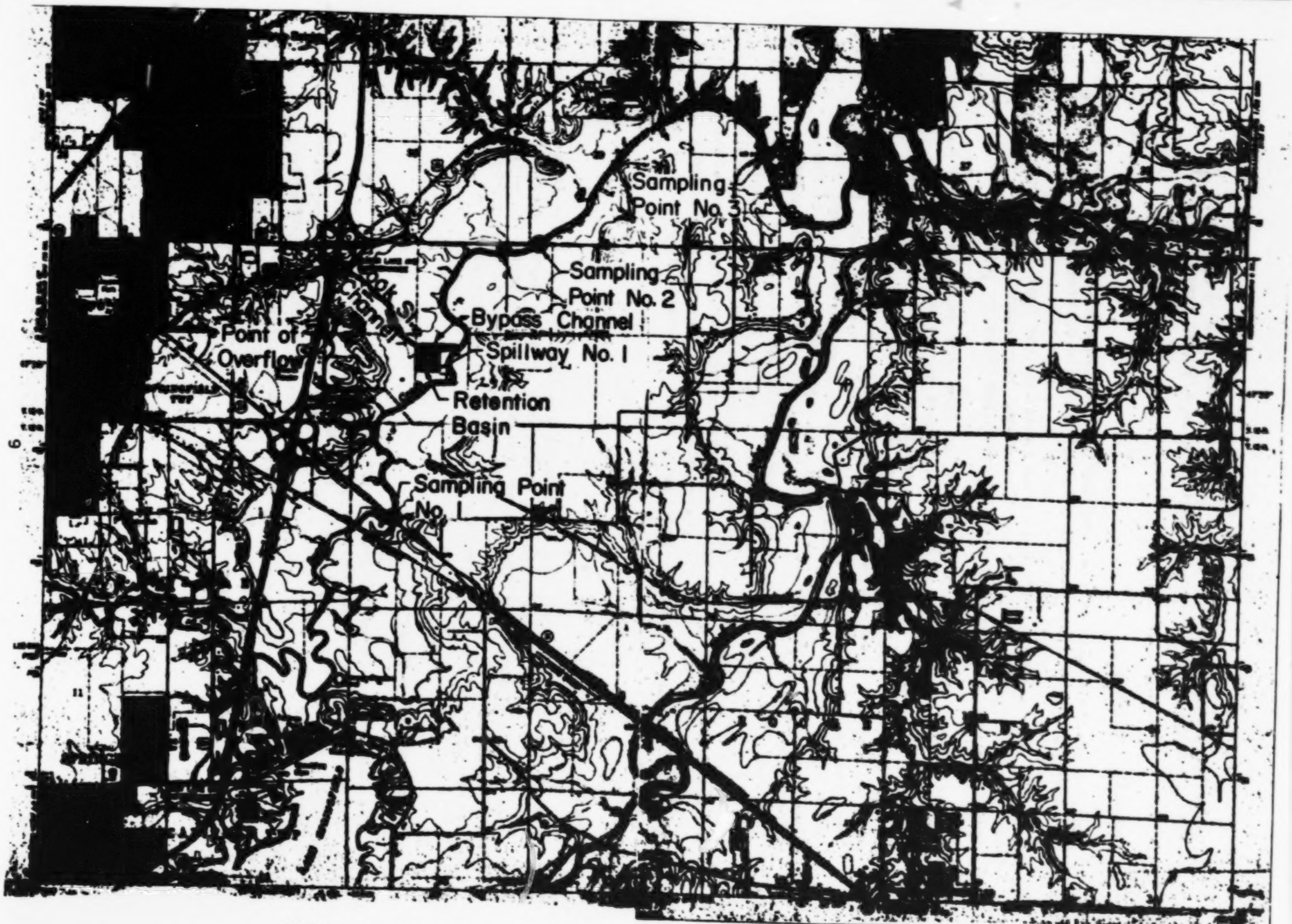
Sampling Point No. 3
Sampling Point No. 2
Bypass Channel
Spillway No. 1
Retention Basin
Sampling Point No. 1
ook St. Channel
Point of Overflow

FIGURE 6. Location of Project and Related Features

in the South Fork of the Sangamon River, no water quality problems in that stream have been associated with the Cook Street Pumping Station.

Concept of Project

Analysis of the nature of the overflow problem along with evaluation of land use patterns and consideration of possible alternative solutions led to a proposal for construction of a retention basin as a means of abating the pollution problem caused by the Cook Street combined sewer overflow. It was envisioned that the retention basin could function in several ways to improve conditions in Sugar Creek.

By use of such a facility a sustained low rate of flow to the stream would be substituted for the high rate, short duration, flow characteristic of storms. Even with no attenuation of waste constituents in the lagoon this elimination of the "shock" effect itself was considered to be an important merit of the proposed system. Also, the low quality, "first flush" characteristic of the initial runoff from urban areas (2) would be diluted in the basin with the subsequent discharge prior to release to the stream. In addition, retention of the storm water overflow in a quiescent basin could be expected to accomplish considerable removal of suspended solids and some removal of BOD. To illustrate, laboratory studies by Evans (3) suggested that 5 hour retention time might account for approximately 70 percent removal of suspended solids and 30 percent removal of BOD. Further improvement might occur due to biological degradation of the nonsettleable organic constituents and die away of pathogenic organisms contained in the overflow.

Objective of Study

The purpose of the study was to evaluate the performance of the retention basin under actual operating conditions so as to permit prediction of the probable performance of similar basins at other installations and to obtain information which would be useful in developing design criteria for such combined sewer control facilities.

Organization of Study

The work was conceived, organized and carried out by the Springfield Sanitary District. The consulting engineering firm of Jenkins, Merchant, and Nankivil, Springfield, Illinois prepared the plans and specifications for construction of the retention basin and associated facilities. During the period of evaluation of lagoon performance, sample collection and laboratory analyses were carried out by personnel of the Springfield Sanitary District. In the early phases of the study, bacteriological tests were conducted by the Division of

Laboratories of the Illinois State Department of Public Health. The consulting firm of Ewing, Engelbrecht and Associates assisted with procedural matters during the period of evaluation of lagoon performance and cooperated in analyzing the data collected by Springfield Sanitary District personnel. Drs. John Melin and Ronald Woodhead were responsible for computer analysis of the data. This report was prepared jointly by personnel of Ewing, Engelbrecht and Associates and of the Springfield Sanitary District.

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SECTION III

DESIGN OF RETENTION BASIN

The site selected for construction of the retention basin was at the confluence of the channel carrying the Cook Street overflow with Sugar Creek as shown in Figure 7. The site was 9000 ft from the Cook Street Pumping Station and was remote from developed parts of the city of Springfield. The nearest residential area was approximately 1500 ft from the site. Figure 7 shows some of the details of the basin and an aerial photograph taken prior to construction of the sampling facilities is included as Figure 8.

The levees forming the basin rose 14 ft above the basin bottom and the 10 ft top width of the levees was surfaced with crushed stone to provide an all-weather roadway. Inner and outer side slopes were three horizontal to one vertical. The levees were continued along the Cook Street outlet channel for some distance upstream to prevent overflow of that channel when the lagoon water depth was great. Also included in the design were a surfaced access road, supplementary perimeter drainage, drainage structures, and fencing.

The lagoon was designed to retain a flow of 104 cfs. A ten-acre surface area was selected and at the 104 cfs flow rate, the theoretical retention time would be slightly less than 8 hr.

To minimize necessary operational attention, overflow spillways from the lagoon were designed to automatically control flow. The principal element in the flow control scheme was spillway No. 1. Figure 9 illustrates the nature of that spillway. It was equipped with a slot 3 ft wide and 2 ft deep below the crest of the main spillway. The bottom of the slot was 4 ft above the floor of the lagoon and hence that was the minimum water depth. Normal dry weather flow in the Cook Street outlet channel passed through the slot. The slot in the No. 1 spillway served as a constriction to limit the rate of outflow of sudden discharges produced by combined sewer overflow. Such storms were accompanied by an increase in the depth of water in the lagoon with an accompanying increase in outflow, but because of the spillway contraction caused by the notch, the overflow was retained and permitted to discharge at a moderate rate over a long period of time.

Significant quantities of combined sewer overflow could cause the pool depth to increase to 6 ft and at that point the major portion of the No. 1 spillway would begin to function. If the depth increased to 7 ft, which corresponded to the 104 cfs flow rate, spillway No. 2 located near the entrace to the basin began to function, bypassing flow, past the lagoon. Figure 10 (taken, with some modification from Jenkins, Merchant, and Nankivil, 1965) illustrates the depth-discharge relationship for the spillways and Figure 11 contains a tabulation of

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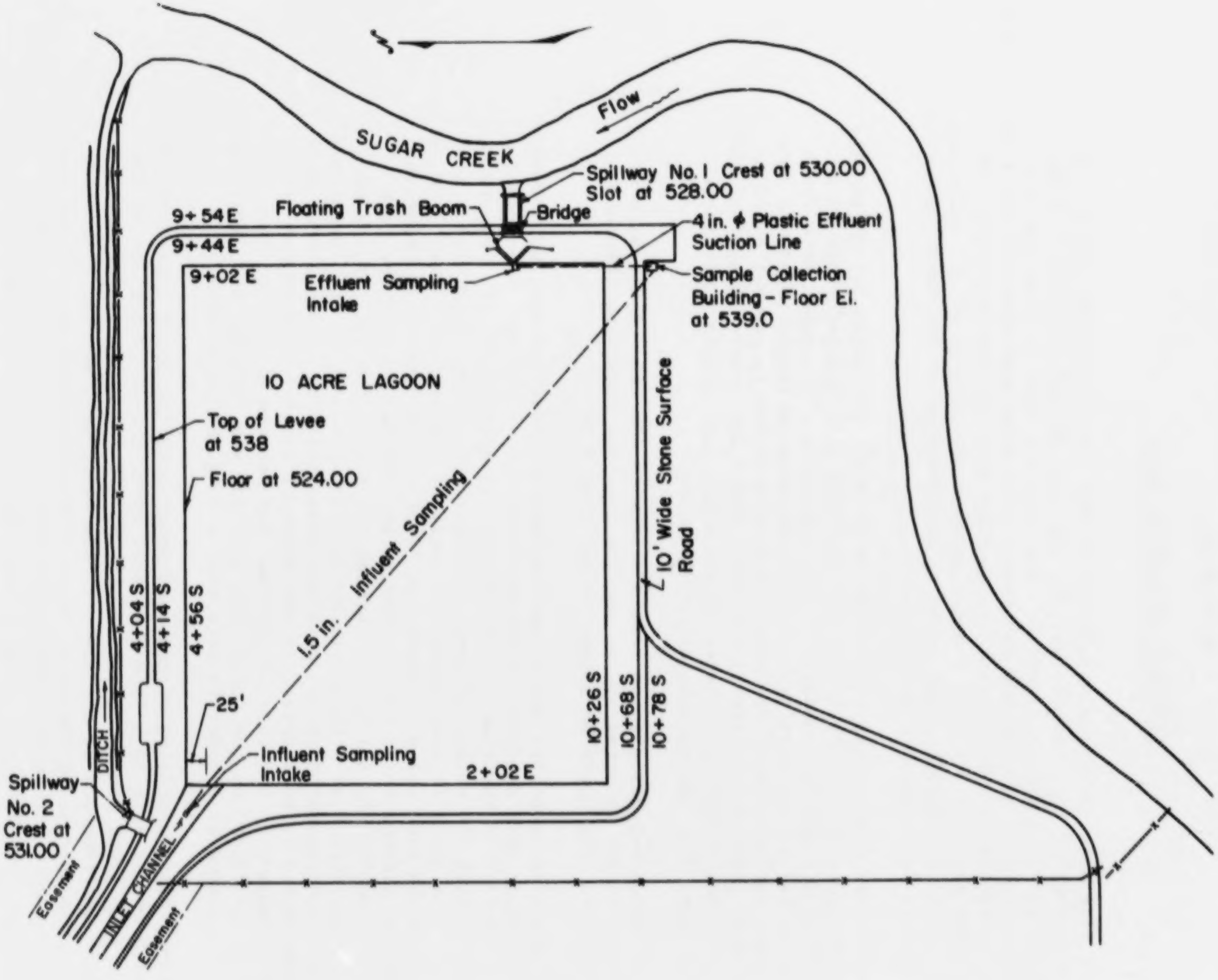

SUGAR CREEK
Flow
Spillway No. 1 Crest at 530.00
Slot at 528.00
Floating Trash Boom
Bridge
4 in. ϕ Plastic Effluent Suction Line
Sample Collection Building - Floor El. at 539.0
9+54E
9+44E
9+02E
Effluent Sampling Intake
10 ACRE LAGOON
Top of Levee at 538
Floor at 524.00
1.5 in. Influent Sampling
10' Wide Stone Surface Road
4+04S
4+14S
4+56S
25'
Influent Sampling Intake
2+02E
10+26S
10+68S
10+78S
DITCH
Spillway No. 2 Crest at 531.00
Easement
INLET CHANNEL
Easement

FIGURE 7. Plan of Retention Basin

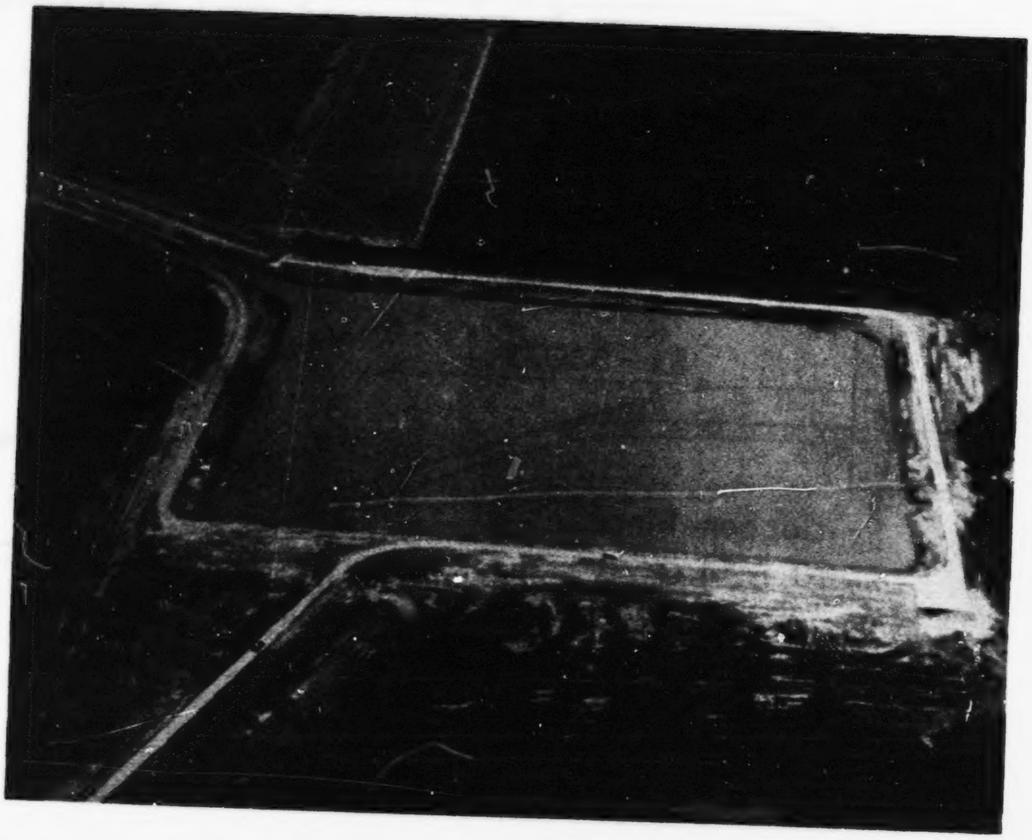
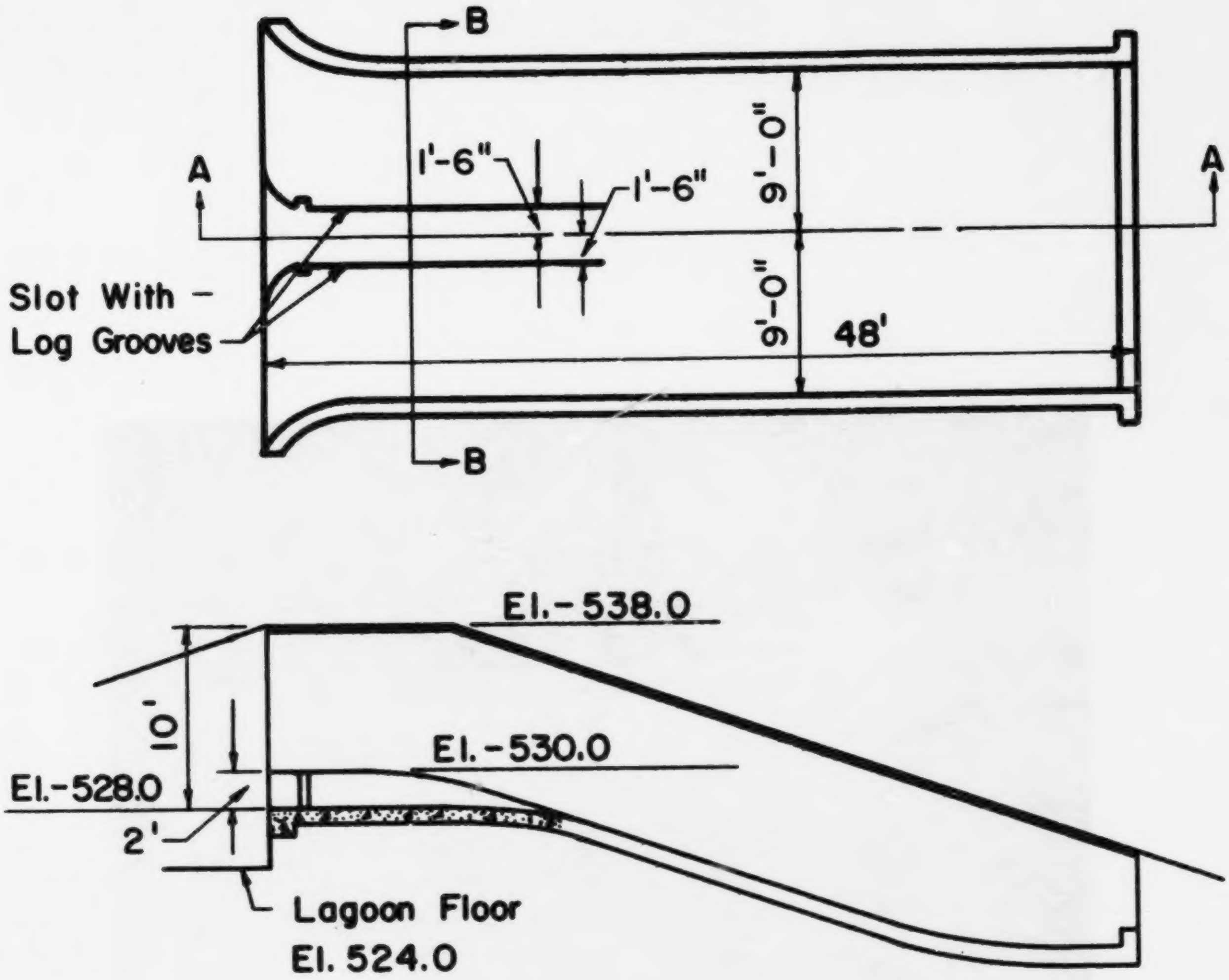
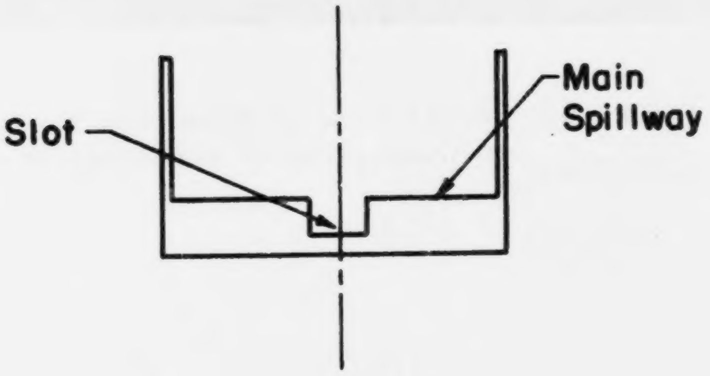


FIGURE 8. Aerial View of Retention Basin Prior to Completion of Construction


B
A
1'-6"
1'-6"
9'-0"
A
Slot With -
Log Grooves
9'-0"
48'
B
El. - 538.0
10'
El. - 530.0
El. - 528.0
2'
Lagoon Floor
El. 524.0

Section A-A


Slot
Main
Spillway

Section B-B

FIGURE 9. Detail of Slotted Spillway

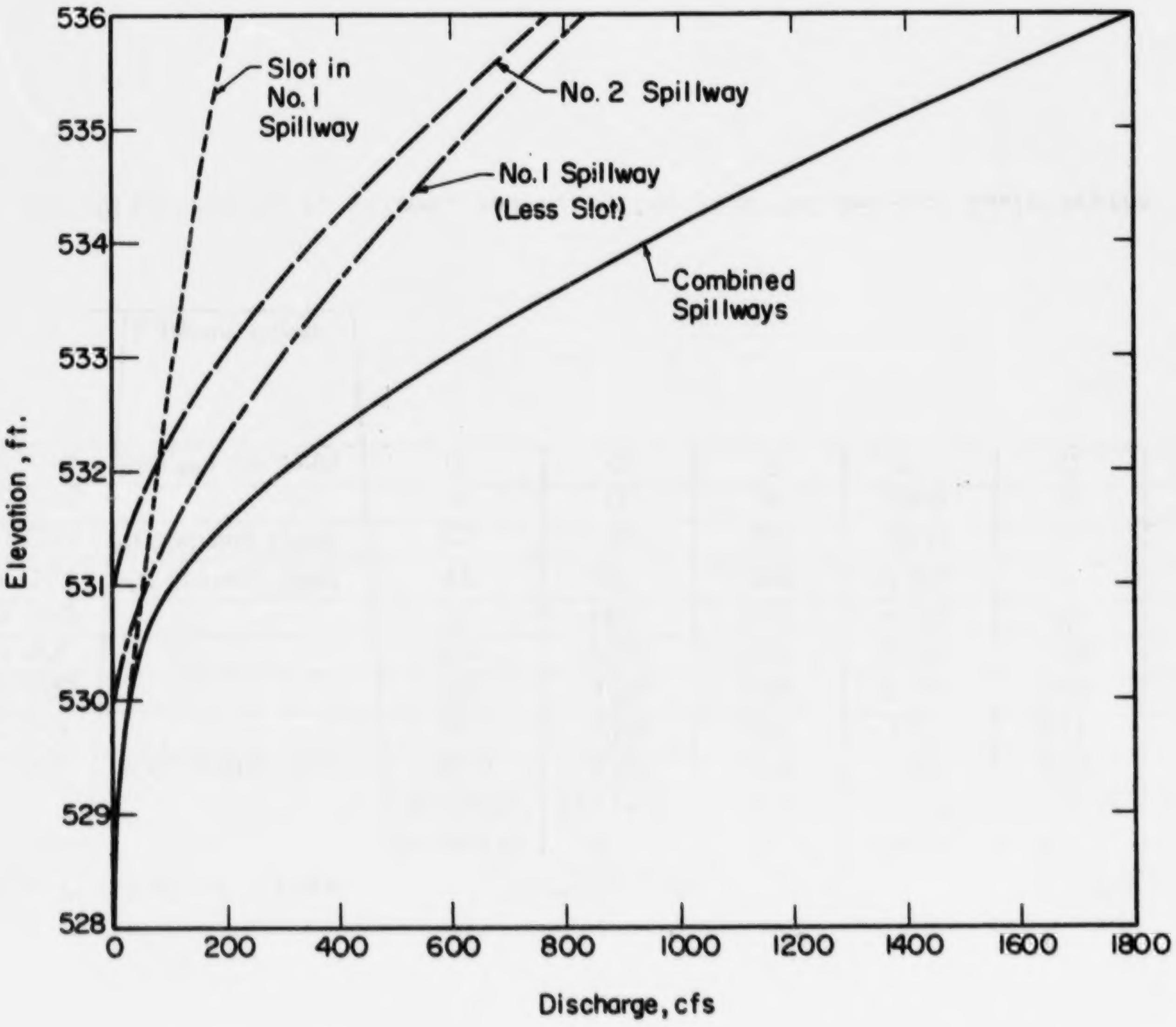
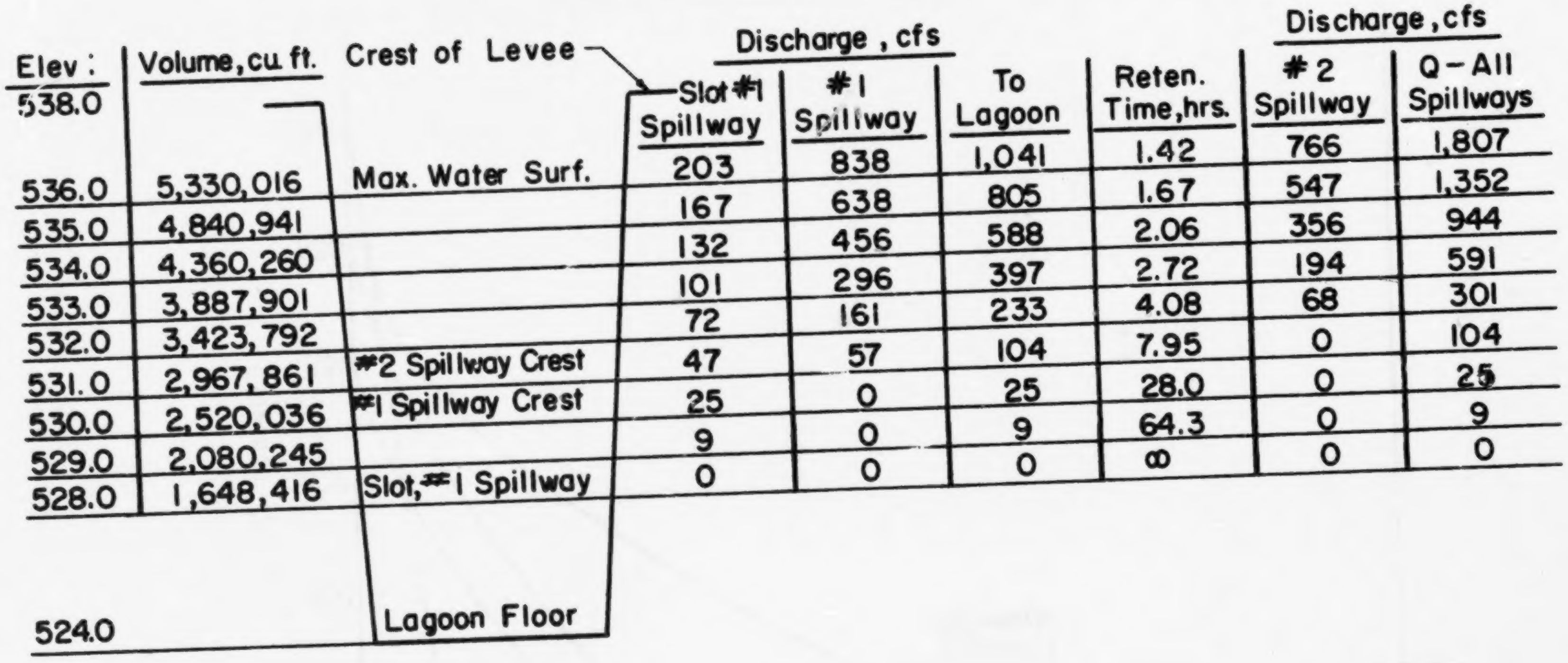


FIGURE 10. Depth Discharge Relationship for Basin Spillways



			Discharge, cfs				Discharge, cfs	
Elev.:	Volume, cu. ft.		Slot #1 Spillway	#1 Spillway	To Lagoon	Reten. Time, hrs.	#2 Spillway	Q – All Spillways
538.0		Crest of Levee						
536.0	5,330,016	Max. Water Surf.	203	838	1,041	1.42	766	1,807
535.0	4,840,941		167	638	805	1.67	547	1,352
534.0	4,360,260		132	456	588	2.06	356	944
533.0	3,887,901		101	296	397	2.72	194	591
532.0	3,423,792		72	161	233	4.08	68	301
531.0	2,967,861	#2 Spillway Crest	47	57	104	7.95	0	104
530.0	2,520,036	#1 Spillway Crest	25	0	25	28.0	0	25
529.0	2,080,245		9	0	9	64.3	0	9
528.0	1,648,416	Slot, #1 Spillway	0	0	0	∞	0	0
524.0		Lagoon Floor						

FIGURE 11. Discharge Rate, Volume, and Retention Time for Various Basin Depths

flows which would occur at various water surface elevations along with other pertinent basin data. The combined capacity of the No. 1 and No. 2 spillways, which were constructed of reinforced concrete with interlocking steel sheet piling cutoffs at both the upstream and downstream ends, was 1807 cfs. This flow corresponds to the predicted flood flow which would occur with a 75 year frequency. Additional emergency capacity to handle greater flows was provided in the form of a "fuse plug" section of the levee which would fail during extreme flood conditions. It is anticipated that during these conditions the entire area adjacent to the lagoon would be inundated such that the damage to the basin levee would be minimal.

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SECTION IV

CONSTRUCTION OF BASIN

The retention basin was constructed, utilizing two contracts. One contract included the basic construction of the pond, levees and spillways, including necessary roadways and seeding of the levee banks. The second contract consisted largely of the instrumentation required for the study including flow measurement equipment, sampling equipment, a building to house the sampling and flow measurement equipment, and, in addition, fencing of the lagoon and the erection of a trash boom at the lagoon effluent spillway No. 1.

Bids were taken on the basic retention basin contract on October 4, 1966. Construction was started on October 28, 1966. Construction on this contract was scheduled to be completed February 28, 1967. However, flood conditions were experienced in early December of 1966, which placed the whole site under water for a considerable period of time and made working conditions impossible. Further flood conditions were experienced during the late winter and early spring of 1967 and served to further delay the completion of this contract. Actual construction on the basic contract was completed July 10, 1967. Bids were received on the instrumentation contract on July 25, 1967. The bids on this contract were considerably over the estimate. As a result there was some delay between the time that bids were received and approval was obtained from the Federal Water Quality Administration to accept the low bid and award a contract. Such approval was received September 14, 1967. The contractor started work October 8, 1967. This contract was to be completed January 16, 1968. Again, because of flood conditions existing at the lagoon, work under this contract was delayed and was finally finished on March 25, 1968.

The estimate of cost of the basic contract for basin construction was $94,723.10. Nine bids were received on this contract, with Freesen Brothers Inc. of Bluffs, Illinois, being the low bidder at $75,384.26. The estimated cost of the instrumentation contract was $14,743.00. Four bids were received on this contract, with the low bidder being Jack Finley Company of Springfield, Illinois, at $28,342.00. If the estimates on the basic pond construction and instrumentation are combined, they total $109,466.10. The combined actual low bids on the basin construction and instrumentation total $103,726.26. Therefore, while the instrumentation bid was considerably above the estimate, the fact that the basic bid was below the estimate, allowed the entire work to be done within the money available for the project. The final contract cost was $77,478.91 for the construction of the retention basin including all extras. The final cost of the instrumentation contract including all extras was $31,257.00. The combined total cost of both contracts was $108,735.91 which was within the estimated cost of $109,466.10. Photographs taken during construction of some of the major elements of the lagoon are shown in Figures 12, 13, and 14.

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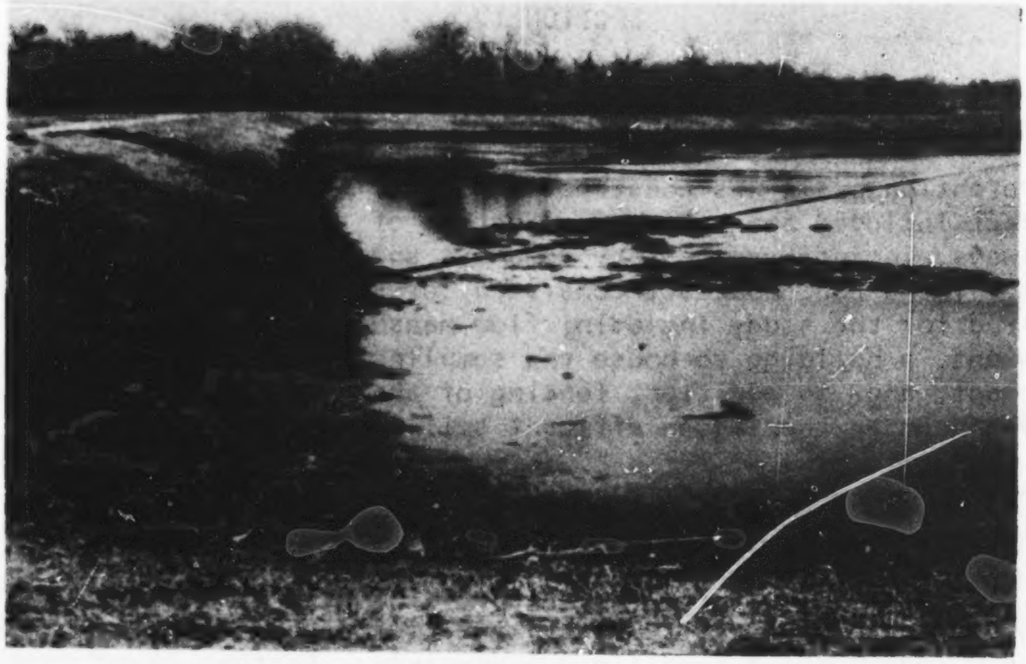

FIGURE 12. General View of Basin Showing Influent and Effluent Sampling Pipes

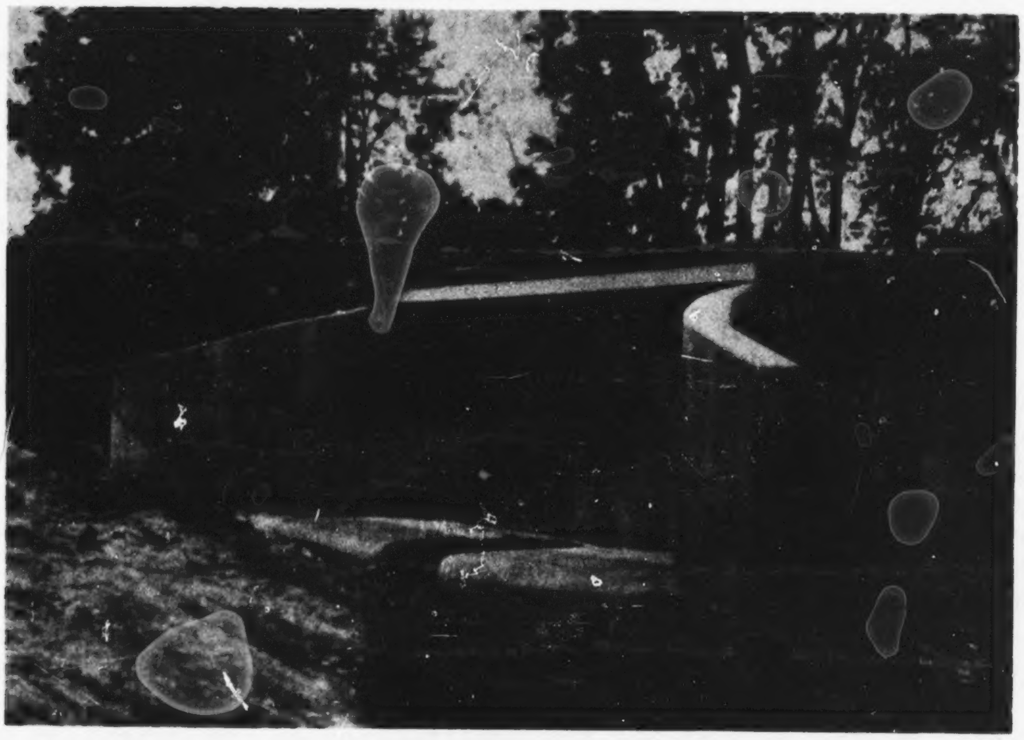

FIGURE 13. Entrance End of No. 1 Spillway. View looking North-East

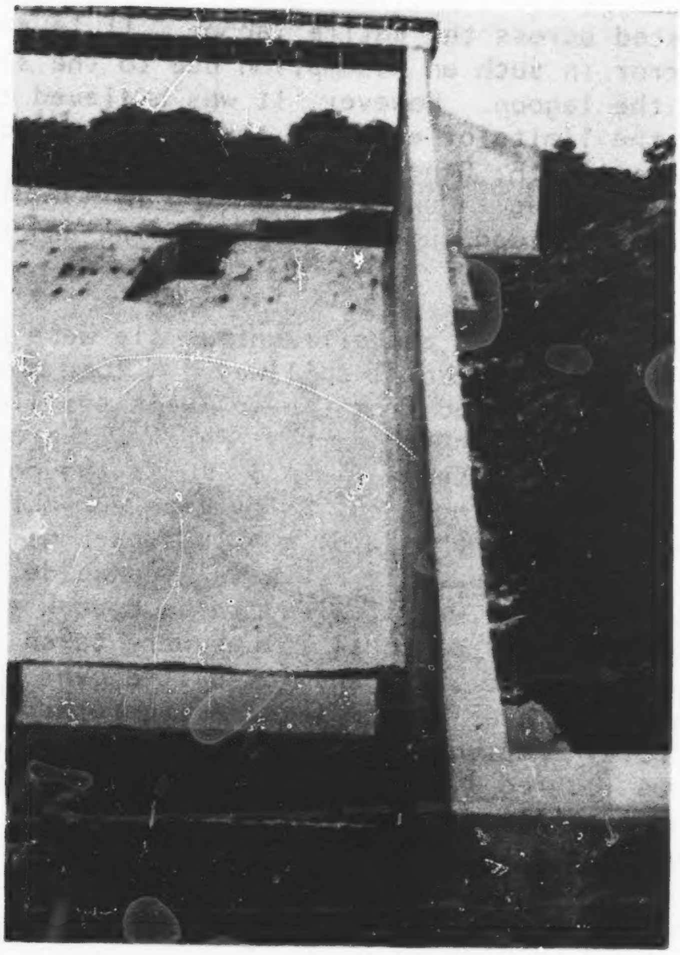

FIGURE 14. View of No. 1 Spillway Looking West Along North Retaining Wall

The rate of flow out of the basin was determined by measuring the head over the spillways. Rating curves for both No. 1 and No. 2 spillways were developed and were combined to provide a rating curve from which the cam for the recording instrument could be cut. The head over these spillways was measured with a pneumatic instrument. The meter measured the head at the No. 1 spillway and it was assumed that the same elevation persisted across the entire lagoon. It is recognized that there is some error in such an assumption due to the slight hydraulic gradient across the lagoon. However, it was believed that such difference was within the limits of error of the measuring equipment. The recording instrument (BIF, General Signal Corporation, Providence, Rhode Island) was located in the equipment building adjacent to the No. 1 spillway and provided indicating, recording and totalizing of the flow.

Both the influent sample and the effluent sample were pumped to the equipment building near the No. 1 spillway. A long suction line, four in. in diameter, was provided from the influent sampling point to the building and a short line of the same diameter was provided from the effluent sampling point to the building. Pumps (Moyno Pump Division, Robbins & Meyer, Inc., Springfield, Ohio) located in the equipment building took suction from the sampling lines, discharging into a sampling tank. A scoop-type sampler, (Trebler, Lakeside Equipment Corporation, Chicago, Illinois) was provided in each tank to take the samples (Figure 15). Samples of equal volume were taken at 30 min intervals with the automatic samplers and composited over a 24 hr period. The composite bottles were located in a refrigerator and were kept under mechanical refrigeration at all times. The point of sampling in each instance was located 1.5 ft below the water surface when at the notch in the No. 1 spillway or 2.5 ft above the lagoon bottom. Some problems developed as a result of this which will be discussed later, and the influent sample inlet was changed to permit withdrawal of a sample 6 in. below the basin water surface.

FIGURE 15. Sampling Tank and Sampler Located in Sample Collection Building

FIGURE 15. Sampling Tank and Sampler Located in Sample Collection Building

SECTION V

OPERATION OF BASIN

The retention basin and equipment operated satisfactorily overall during the period of study. Figure 16 shows the basin in operation and is a view facing the inlet channel. The overflow through the No. 1 spillway is shown in Figure 17; floating algae may be seen. There were several things upon which a comment might be made with regard to both design and operation of the installation. In an effort to economize on construction costs, flanking levees were built on each side of the inlet channel into the pond for a considerable distance back from the pond. This was done in lieu of constructing the basin several feet deeper. This in effect made the inlet channel a part of the basin itself. In operation of the basin it was found that during the lower flows, solids would settle out in this part of the inlet channel formed by the flanking levees. During heavier flows, the solids so settled apparently were washed into the basin and very largely deposited close to the inlet point rather than being dispersed more evenly over the entire pond bottom. A considerable amount of sludge accumulated in the basin. The amount was more than was anticipated. The duration of the study was not sufficient to determine whether compaction of the sludge might take place over a period of time to allow the sludge depth to not become of unmanageable proportion. Some problems were also experienced with the sampling equipment but these problems are considered to be typical of those occurring with the start-up of mechanical equipment of most any type.

The retention basin was actually in operation as such from the late fall or early winter of 1967. However, because of delays in installation of equipment, the actual study period was not begun until March 26, 1968. Problems were experienced during the first several months of operation of the basin. Part of this was due to the need to by-pass raw sewage to the basin during dry weather while repairs were being made to equipment at the Cook Street Pumping Station. Problems were also experienced in adjusting the flow meter. This ultimately neccesitated attention by an agent of the manufacturer. This adjustment was not made until approximately June 10, 1968 after which time the flow meter was considered to operate properly. The receiving stream was in flood on at least one occasion during the early months of basin operation and as a result backed into the No. 1 spillway. Flow actually was taking place from the stream, over the No. 1 spillway, into the basin, and flowing out of the basin through the No. 2 spillway. Recorded flow rates during these periods were, of course, erroneous. Photos of such a flooding condition are shown in Figures 18 and 19.

Problems were experienced with operation of the samplers during the early months of the operation. This was particularly true of the influent sampler. Various things were tried to correct the condition and proved unsuccessful and as a result the basin was ultimately drained

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FIGURE 16. View of Basin in Operation Showing Influent Channel in Distance

FIGURE 17. Overflow Discharging to Sugar Creek Through No. 1 Spillway

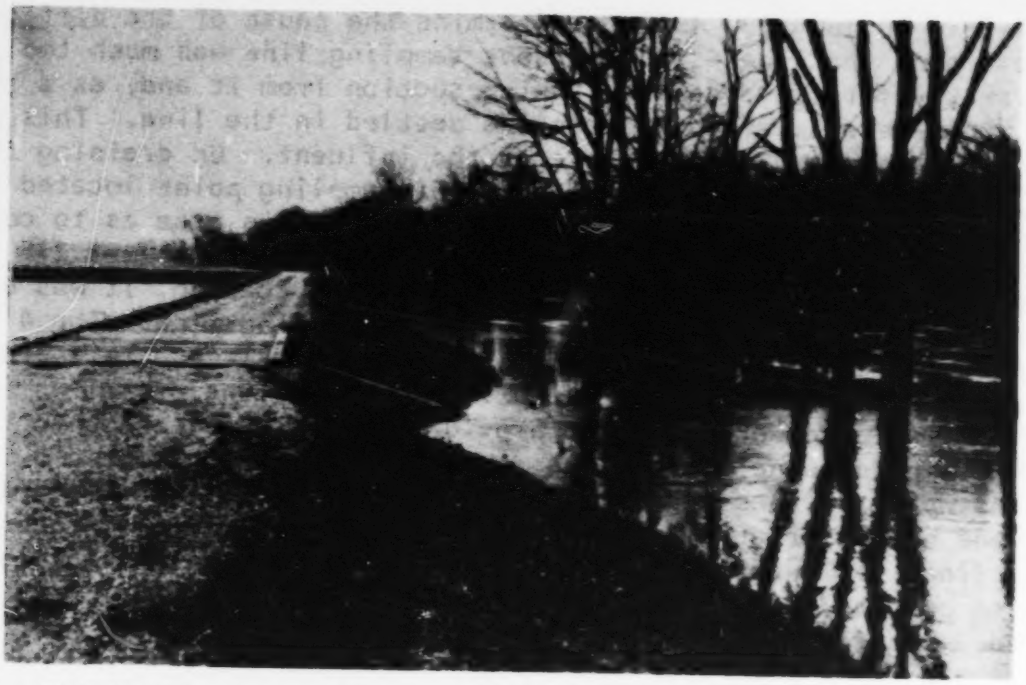

FIGURE 18. View Looking North Along the East Side of the Basin. Because of the Stage of Sugar Creek, Water is Flowing From the Stream Into the Basin

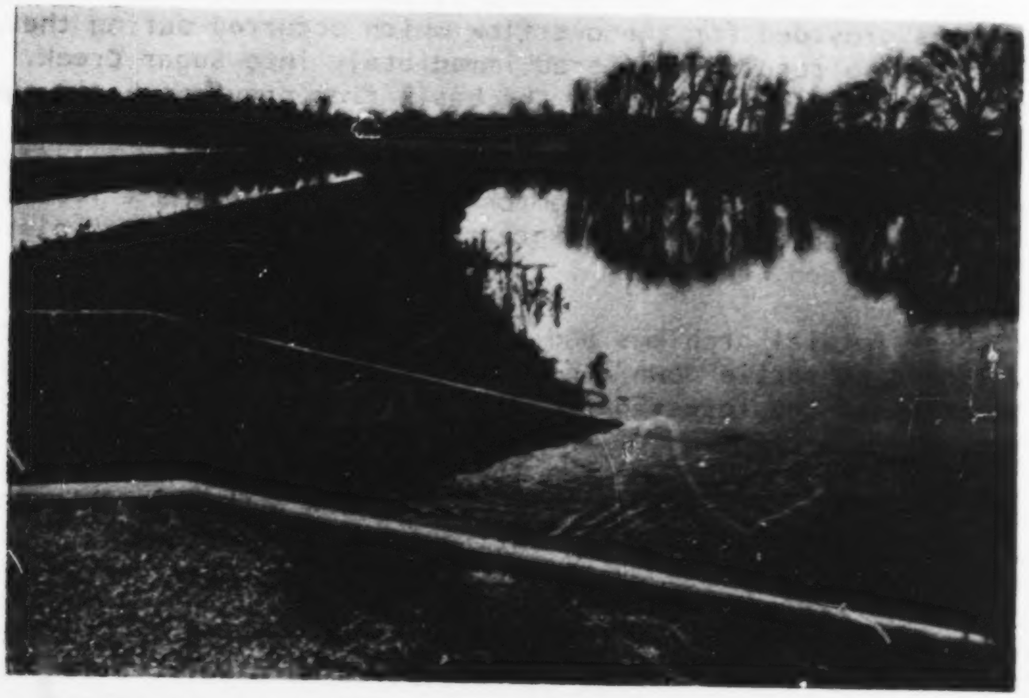

FIGURE 19. View Looking Westerly Along the Entrance Channel Showing the No. 2 Spillway. Water Surface at This Time Was 0.35 ft Lower Than at Spillway No. 1 and Flow Was Out of the Lagoon.

completely on July 12, 1968 to determine the cause of the difficulty. It was found that the 4 in. influent sampling line was much too large in diameter for the size pump taking suction from it and, as a result, considerable amounts of solids settled in the line. This provided a nonrepresentative sample of the influent. On draining the basin, it was found that with the influent sampling point located where it was, sludge had built up to such depths in this area as to completely cover the entrance into the sampling line which was 2.5 ft off the bottom. Since the basin was down on this occasion, it was decided to correct the problem with the oversized sampling line. The 4 in. influent sampling line was replaced with a 1.5 in. line. This provided better velocities in the line and minimized settling of solids in it. A method was also worked out to provide a floating entrance to the influent sampling line whereby the sample was always collected 6 in. below the water surface regardless of depth of liquid in the basin. This was done by constructing a float to carry the end of the influent sampling line. This corrective action appeared to allow the influent sampler to operate satisfactorily during the balance of the investigational period.

The drain valve was closed and the basin allowed to refill on July 22, 1968. During the time when the basin was drained and no detention was provided for the overflow, two periods of heavy rain occurred. On July 15, rainfall in the amount of 0.85 in. was experienced. On July 16 rainfall was 0.23 in. and on July 17 rainfall was 0.80 in. No detention was provided for the overflow which occurred during these storms and as a result it entered immediately into Sugar Creek. Also, with the solids accumulation in the basin from previous basin operations, solids were swept out into the stream and placed an even heavier load on Sugar Creek than would have been the case if the overflow were discharged directly to the stream on this occasion. As a result, the only fish kill on Sugar Creek since the retention basin was placed into operation occurred.

After these initial problems had once been resolved, operation of the basin seemed to settle down and presented no particular problems for the duration of the investigational period. Occasional problems were experienced with clogging of the influent sampling line, however. These were resolved by blowing out the line with compressed air and repriming the sampling pump. No problem was experienced with regard to the effluent sampling line during the entire course of the survey. It is believed that the principal problem that was experienced on the influent sampling line resulted from having an extremely long line between the point of sampling and the pump. This could have been resolved readily by installing a pump and sampling facilities at a point close to the influent sampling point. However, this would have necessitated the installation of additional power lines and would have substantially increased the cost of the project. It was felt that this kind of cost increase was not warranted by the results which might possibly be obtained.

Virtually no maintenance or cost was involved in the actual operation of the basin itself. Almost all costs were associated with the study of basin performance. Crown Vetch was used for seeding the banks of the levees instead of grass seed. As a result, there were no costs associated with mowing of the banks during the study. No work was necessary on the road on the basin levee during this time. However, a small amount of work was required on the Township Road leading to the facility. In order to make this road passable it was necessary for the Sanitation District to do the maintenance work on the road rather than wait for the Township to get it done. These costs, however, were minor.

A listing of maintenance required on the various items of equipment is chronologically stated as follows:

June 10, 1968 - Repair flow meter
July 10, 1968 - Repair influent sampling line
July 12, 1968 - Repair influent sampling line
July 15, 1968 - Repair influent sampling line
July 16, 1968 - Repair influent sampling line
July 17, 1968 - Repair influent sampling line
July 22, 1968 - Repair influent sampling line
August 1, 1968 - Repair influent sampling pump
August 16, 1968 - Repair effluent sampling pump
August 19, 1968 - Sampler motor on influent sampler burned out; install new motor
November 5, 1968 - Repair both influent and effluent sampling pumps
November 6, 1968 - Repair both influent and effluent sampling pumps
November 8, 1968 - Unclog influent sampling line
November 12, 1968 - Unclog influent sampling line
November 14, 1968 - Unclog influent sampling line and repair sampling pump
November 29, 1968 - Repair both influent and effluent sampling pumps
January 14, 1969 - Repair heater in instrument building
March 4, 1969 - Unclog influent sampling line
March 5, 1969 - Unclog influent sampling line
March 6, 1969 - Unclog influent sampling line
April 11, 1969 - Unclog influent sampling line
June 16, 1969 - Unclog influent sampling line

During the entire period of the survey operation, maintenance cost for labor was $1,887.76 and maintenance cost for equipment was $618.76 or a total cost for both labor and equipment of $2,506.52 for the period March 26, 1968 through November 30, 1969. Of course, other costs were experienced for the operation of sampling and flow measurement equipment and collection of and bringing the samples into the laboratory as well as laboratory analysis of the samples collected. These are direct costs of the actual investigation and should not be charged as costs of basin operation. Actually, virtually all of the maintenance costs listed above should also be considered as costs of the investigation rather than costs of the basin operation.

The cost of operating the retention basin was as follows:

Expenditure*	Annual Cost	Total** Cost
Power to operate sampling and flow measurement equipment	$ 162.47	$ 273.52
Road maintenance	181.65	305.80
Repair replacements and maintenance of sampling and flow measuring equipment	1,274.94	2,146.36
Salary of sample collector	5,875.28	9,891.05
Travel expenses of sample collector	1,697.42	2,857.61
Laboratory equipment and reagents	1,847.27	3,109.88
Salary of chemist	6,338.12	10,670.24
Administration cost associated with pond operation (excluding that for general administration, report preparation, etc.)	121.97	205.33
	$17,499.12	$29,459.79

*All fringe benefits are included where salary is involved.

**Total cost included that for the entire investigational period, March 26, 1968 through November 30, 1969.

It may appear from the above that unusually high costs were occasioned for laboratory equipment and reagents. This was necessary because the State of Illinois Division of Laboratories discontinued making the bacterial analyses and the Division of Sanitary Engineering could not complete the biological investigation. It was, therefore, necessary for the Sanitary District to purchase the necessary laboratory equipment and supplies so that the District itself could take over this function which was not planned originally to be done by the District. Some other costs involved are considered to be unusually low. The salary of the chemist during the survey is quite low. This was due to the fact that it was possible to engage a part-time student chemist to do the necessary laboratory work. The persons who were engaged had previous chemistry background and were entirely qualified to do the necessary laboratory work. Costs were also reduced for the sample collector inasmuch as it was possible to utilize one of the District personnel on a part-time basis for collection of the necessary samples occasioned by the investigation. The balance of his time was taken up with other duties and, therefore, only a part of his time was chargeable against the cost of the investigation.

A number of problems were encountered in the operation of the study. Certain of these were problems associated with start-up of the study which included mechanical difficulties with equipment as well as the necessary changes in procedures that are occasioned in the normal start-up of such a study. Some of these items have been discussed previously but are again mentioned here. Problems were encountered with the flow meter during the first several months. The flow data are not considered representative until after June 13. Sludge was found to be settling out to some extent in the sampling tanks due to the long holding time in the tanks. This was corrected by reducing the holding time in the sampling tanks to a minimum. This problem was also corrected in June. Some mechanical problems were experienced with the samplers at the start-up of the investigation. These again were corrected within the first few months. An investigation of sampling locations indicated the point at which the influent DO sample was collected was not providing a representative sample. Due to conditions existing at that point, there was some aeration taking place which was indicating a higher dissolved oxygen concentration than was actually representative. This was also corrected by the end of June.

Because of the many problems encountered during the first few months of the study it was necessary to eliminate much of the early data on pond performance. Most of the start-up problems were eliminated by the beginning of August, 1968 so that it was not necessary to cast out large blocks of data beyond that date.

Among the other problems that were experienced in the conduct of the investigation, perhaps the most persistent was the one involving the clogging of the influent sampling line. The reasons for this are believed to be several. Originally the 4 in. sampling line was much too large and allowed sedimentation of the solids in the line. This was corrected in July, 1968 by the abandoning of the 4 in. line and the installation of the 1.5 in. line in its place. However, it is believed that even this could be improved upon were this investigation being set up all over again. Placing the influent sampling pump closer to the point of collection of the sample would have provided a much more satisfactory operation. However, because of costs and the physical difficulties involved it was not possible to do this in this investigation once the investigation was initiated. It is also believed that the point selected for collection of the influent sample was a poor choice. It developed from operation of the basin that many solids were settling out in the back water within the flanking levees along the inlet stream and then were being washed into the lagoon and deposited out in the immediate area of the influent sampler intake. This is believed to have given some high results particularly on BOD at times when no flow was coming into the lagoon. It was mentioned previously that flanking levees were utilized to permit constructing the lagoon at the shallower depth. It has also been mentioned that the considerable amount of sedimentation of solids took place in the area of the influent stream formed by the flanking levees. This, of course, made it extremely difficult to try to get a representative sample of the waste flowing into the lagoon. It would seem that for a similar study in the future, flanking levees should not be utilized and that the additional costs required to provide necessary depth in the lagoon would be justified in order to get more representative results. Insofar as an operating lagoon is concerned, the flanking levees would seem to be satisfactory. They would provide the required capacity and would yet trap the solids within the lagoon as is desired with this type of operation.

Some problems were encountered mechanically with the sampling pumps. This was anticipated at the time the investigation was set up. Because of the power situation at the area of the lagoon, low capacity pumps had to be utilized. As a result, it was decided to operate pumps used for sampling on a continuous rather than an intermittent basis. Of course, with continuous operation mechanical problems were much more likely to develop. This did not present any great difficulties insofar as operation of the investigation was concerned since an extra sampling pump and motor had been provided originally. It was possible, therefore, to install a new pump and motor very quickly when one became inoperative, repair the inoperative pump and have it available for emergency operation the next time the problem developed.

Several phenomena occurred during the course of the survey which are a little difficult to explain. One of these involved an algae die-off early in the course of the study. As was expected a prolific algae growth developed in the retention basin early in the spring of 1968. This persisted until about the 6th of May when suddenly the algae died off. As a result, the available dissolved oxygen was quickly depleted and the basin became septic. This was the only occasion on which this occurred. It was found that a fire had occurred immediately before this time which completely destroyed a chrome plating plant in the area of the city served by the basin. It can only be speculated that the plating wastes discharged to the sewer were in some measure also discharged into the basin during the period of rainfall, creating a toxic condition for the algae and thus caused the situation to develop as it did. This hypothesis is further borne out by the fact that at the same time a complete upset was experienced at the sewage treatment plant of the Sanitary District in which the activated sludge was virtually entirely destroyed. It would, therefore, seem reasonable to believe that the algae die-off in the pond was due to plating wastes reaching the basin as a result of the fire.

Another phenomena, which cannot be explained, is the fact that during the months of August and September in both years of the study, BOD values appeared to be unusually low. This was particularly true on the upstream sampling station (Station No. 1) above the point of retention basin discharge. The problem was not as pronounced in the year 1968 as it was in the year 1969. In the year 1969, several instances of no measurable BOD were noted in the stream during the month of August. Unusually low BOD values were also experienced during the month of September. To explain this observation, both the sampling and laboratory procedures were investigated. As a result, it did not appear that there was anything relating to procedures, reagents used, or equipment used in analyzing the samples that could account for this situation. No change had been made in sampling procedure, so therefore this could not be held accountable. It, therefore, must be presumed that there was something occurring in the stream which caused this situation to develop. The cause would seem to be seasonal inasmuch as it only occurred at that particular period of the year.

A problem developed in performing the bacterial analyses during the spring of 1969. It was contemplated from the start of the study that the State Department of Public Health, Division of Laboratories, would do all bacteriological and biological work required in the course of the investigation. The bacteriological analyses were made in the State Laboratories until March 24, 1969, when they were suddenly discontinued. The Governor of Illinois, because of a financial crisis in the State government, had decreed an austerity program which did not allow the Division of Laboratories to continue with investigational work of the kind that was being done in this instance. As a result, attempts were made to find another laboratory that could make the bacterial analyses. After making a number of unsuccessful inquiries, it was decided to train personnel in the Sanitary District laboratories and to provide the necessary equipment for them to make the bacteriological analyses. As a result, starting August 7, 1969, and continuing until the end of the investigation, the bacteriological analyses were performed in the Sanitary District laboratories. The Division of Sanitary Engineering of the State Health Department was also to provide biological sampling, particularly of Sugar Creek, at intervals during the course of the investigation. One biological investigation was undertaken prior to the retention basin being placed into operation to provide some background data. No other biological investigations were undertaken by the State organization during the course of the investigation. At the time that the Sanitary District personnel were assuming the responsibility for making the bacteriological analyses, it was also decided to undertake the biological investigations. This was also done and the results reflect the efforts of the Sanitary District personnel during the last few months of the investigation. It was also contemplated that a fish assay would be made of Sugar Creek below the point of discharge of the retention basin prior to placing the facility in operation and again near the end of the survey. This work was to be done by the State Department of Conservation. An assay was made of the stream and is reported in Special Fisheries Report #18 of the Illinois Department of Conservation. While this report is not extensive it does give some indication of the fish population of the stream prior to the lagoon being placed into operation. Again, because of the austerity program in State government, it was not possible to make the fish assay that had been contemplated for the time near the close of the investigation.

Another problem occurred at intervals which somewhat hampered the investigation of the pond. Because of the local physical condition, flooding of the receiving stream and, hence, of the basin occurred on a number of occasions during the course of the investigation. A dam forming Lake Springfield exists on Spring Creek, a reasonably short distance above the point of discharge of the oxidation pond. As a result, there was normally not much flow in the stream at time of rainfall. However, on a number of occasions, because of heavy rains, the level of Lake Springfield became unusually high and it became necessary to drop the gates on the Lake Springfield Dam to discharge this surplus water. As a result, the water rapidly filled the entire Sugar Creek Valley stream bed to the point where the level of the stream was higher than the No. 1 spillway so that flow entered the pond through the No. 1 spillway and exited via No. 2 spillway. On one occasion, it is also believed that this situation occurred with no discharge from Lake Springfield. Excessively heavy rains in the eastern part of the Sangamon River watershed caused flooding of the Lower Sangamon on one occasion to the point where flood waters backed into Sugar Creek sufficiently to flood the spillways of the oxidation pond.

Little problem was experienced from odors from operation of the pond. While a considerable amount of sludge existed on the pond bottom on virtually all occasions, it was covered over with water having a reasonable amount of dissolved oxygen present. As a result, odors did not emanate from the pond. There was one occasion of noticeable odor. This was when the pond was drained in July of 1968. At tnis time the solids deposited on the bottom of the basin which were undergoing anaerobic decomposition were exposed to the atmosphere. Odors did develop and complaints were received at that time. However, there were no other occasions when odors were particularly noted at the site or when they were brought to the attention of the Sanitary District by residents in the area.

SECTION VI

SAMPLING AND ANALYTICAL METHODS FOR PERFORMANCE EVALUATION

Sampling

1. Retention Basin. The problems and changes made in collecting samples of the influent flow for analysis have been discussed in Section V. All changes which were made were accomplished early during the performance evaluation period so that all data reported as of August 1968 were collected using the same procedure. Briefly, samples of the influent flow were collected for chemical and bacterial analyses at a point where the inlet channel entered the retention basin. This was done by suspending the sampling pipe 6 in. below the water surface through the use of a float. Flow was withdrawn continuously through a 1.5 in. ABS plastic pipe by a screw rotor type pump to the sampling tank located in the building containing the sampling and flow measurement equipment. The distance between the equipment building and the point of influent sampling was 920 ft. Samples of the effluent flow from the basin were obtained without any problem through a pipe, the inlet of which was located 2.5 ft above the bottom of the basin, discharging to a sampling tank in the equipment building 180 ft away.

Samples of the influent and effluent flow were withdrawn continuously with separate pumps (Moyno Pump Division, Robbins & Meyer, Inc., Springfield, Ohio) operating at a capacity of approximately 240 gph and were discharged into 16 gal sampling tanks with continuous overflow. A scoop sampler (Trebler, Lakeside Equipment Corporation, Chicago, Illinois) was mounted on each sampling tank and collected a constant amount from the composited flow in each tank at 30 min intervals over a 24 hr period. These aliquots were further composited by collection in a 5 gal PVC plastic bottle which was refrigerated. After thorough mixing, a portion of these composite samples were removed and taken to the laboratory for analysis. Except for dissolved oxygen and temperature measurements, all data on the performance of the basin were collected using composite samples collected in the above manner.

It should be noted that the 24 hr period of compositing extended from one morning to the next during the week, with the data being reported as of the date for the terminal day. In the case of weekend data, it was the practice originally to composite samples from Friday morning to Monday morning. This procedure was changed early in the performance study; sampling from Friday morning to Sunday morning was eliminated so that the data reported for each Monday date were obtained from a 24 hr composite sample collected from Sunday morning to Monday morning.

Dissolved oxygen and temperature data for the influent and effluent flow were obtained from grab samples collected, for the most part, at the same location as the continuous sampling but using a portable sampler attached to a pole so that the sample could be manually collected from the shore.

Studies were performed to determine the accumulation of solids in the basin by measuring the depth and distribution of sludge. This was done by boat using a pole to which a piece of masonite, approximately 1 sq ft, was attached perpendicularly.

2. Receiving Stream. Stream samples for chemical and bacterial analyses were collected manually at three different locations as grab samples. A conventional dissolved oxygen sampling container in which the contents of the inserted bottle were displaced three times in its filling was used (6). The filled bottle was used for determining the dissolved oxygen while the remainder of the sample in the container was used for making the other measurements.

Benthic sampling was also performed in making a biological survey to determine the condition of the receiving stream. Further details on this phase of the investigation are provided in Section VII.

All sampling of the basin, including the maintenance of equipment, and the receiving stream was performed by personnel of the Springfield Sanitary District.

Flow Measurements

The effluent flow from the basin was determined by measuring the head over the No. 1 spillway. This measurement was converted to flow by a flow recorder assembly of the air bubbler type, consisting primarily of a pneumatic type transmitter, a source of compressed air, and a receiver fitted for indicating, totalizing and chart recording (Figure 20). The transmitter and receiver were manufactured by BIF, General Signal Corporation, Providence, Rhode Island. There was also a staff gauge located at the point of effluent discharge so as to determine the surface elevation of the water in the basin. The flow meter was calibrated to record the total discharge from Nos. 1 and 2 spillways when the water elevation in the basin exceeded the crest of No. 2 spillway.

There was no provision made to measure the influent flow to the pond. Gross observations of influent flow were recorded by personnel of the Sanitary District at the time of sample collection. Similar observations were made with respect to flow in the receiving stream.

Analytical Procedures

Unless otherwise noted, all analytical determinations were performed by personnel and in facilities associated with the Springfield Sanitary District.

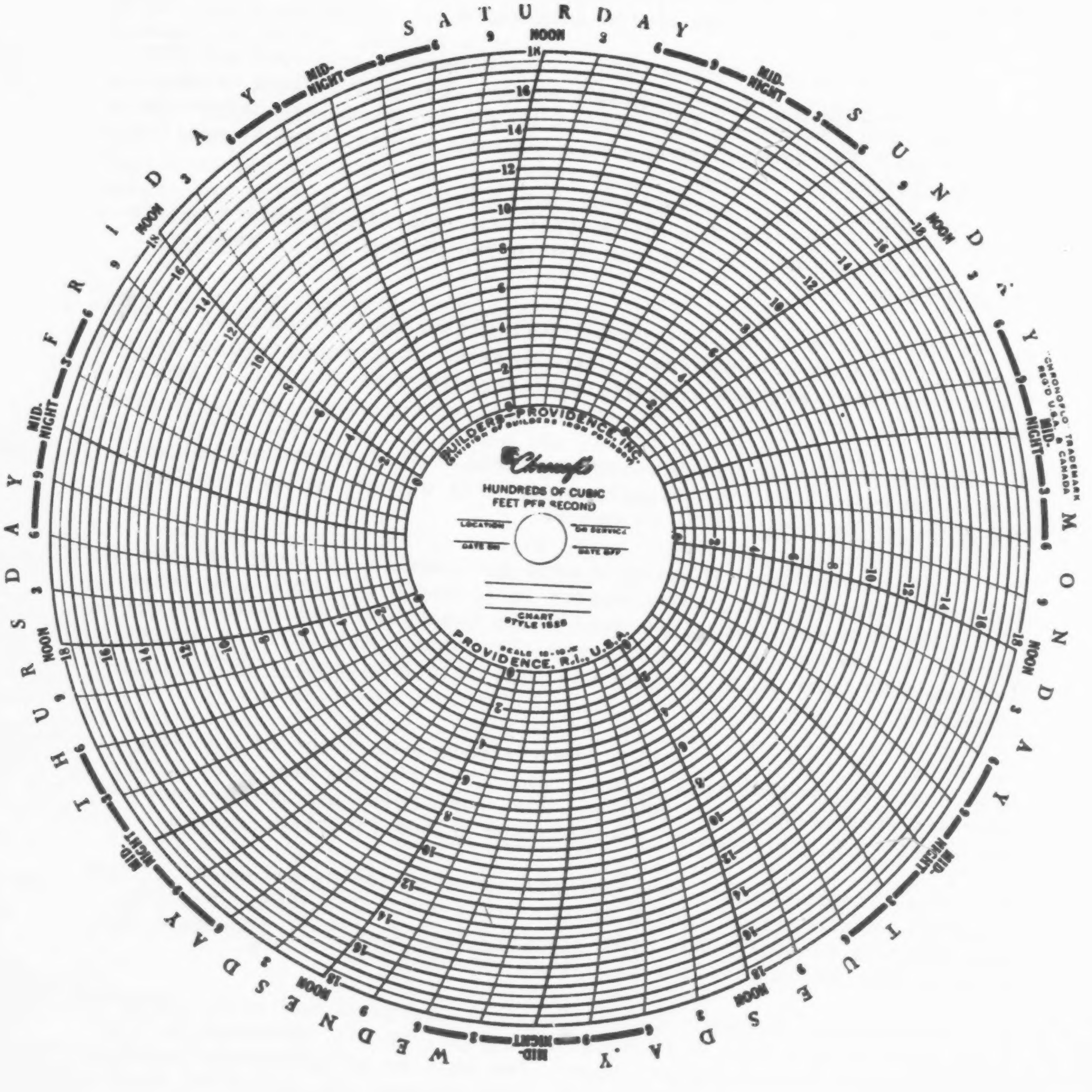

FIGURE 20. Chart for Recording Flow Over No. 1 Spillway

1. Dissolved Oxygen (DO). In all cases grab samples were used for analysis. The Sodium Azide modification of the Winkler procedure was used. Reagents were added to the sample immediately in the field using "pillows" manufactured by Hach Chemical Company, Ames, Iowa. Final titration was performed in the laboratory.

2. Biochemical Oxygen Demand (BOD). The procedure employed was that described by Standard Methods (1965) except that a dissolved oxygen probe was used instead of the Winkler method for dissolved oxygen determination. The probe used was manufactured by Precision Scientific Company, Chicago, Illinois.

3. Solids. Both suspended solids (SS) and volatile suspended solids (VSS) were determined in accordance with the procedures in Standard Methods (1965).

4. Temperature and pH. All temperature measurements were made in the field at the time of sampling. Determination of pH was performed using a meter manufactured by Analytical Measurements, Inc., Chatham, New Jersey.

5. Methylene Blue Active Substances (MBAS). This determination was made by personnel of the Illinois Department of Public Health using the Standard Methods (1965) procedure.

6. Coliform Density. These data were provided by personnel of the Illinois Department of Public Health until March 25, 1969. No determinations were made from this date until August 7, 1969, when personnel of the Sanitary District assumed the responsibility. The procedure used by both organizations was that described in Standard Methods (1965).

7. Fecal Coliform. Initially, the Illinois Department of Public Health was to provide this information. The limited amount of data provided after August 27, 1969 was made available through personnel of the Sanitary District using the Standard Method (1965) procedure.

8. Fecal Streptococcus. Determinations were made by personnel of the Illinois Department of Public Health until March 25, 1969, when the analysis was discontinued. The Standard Methods (1965) procedure employing the membrane filter technique was used.

9. Phosphorus. Determinations for total inorganic and ortho phosphate were made using a test kit, Model PO-21, Deluxe Kit, marketed by the Hach Chemical Company, Ames, Iowa. The meta or polyphosphate concentration was calculated as the difference between the amount of total inorganic and ortho phosphate.

Climatological Data

The average air temperature, wind speed and direction, possible sunshine, and evaporation information were provided by the U.S. Weather Bureau, located at Capitol Airport, Springfield, Illinois.

Rainfall information was recorded as an average using data collected at two different rain gauge locations, one at the City of Springfield, Water Purification Plant and the other located at the Springfield Sanitary District, Cook Street Pumping Station. Both rain gauges were the weighing-recording type, manufactured by Science Associates, Inc., Princeton, New Jersey.

Data Recording, Reduction and Analysis

All laboratory analytical data and observations, regardless of source, i.e. Sanitary District, Illinois State Health Department, or U.S. Weather Bureau, were recorded daily on monthly log sheets. This was done for the retention basin and the receiving stream, using separate log sheets. An example of each log sheet, indicating the data collected and recorded, is given in Appendices III and IV.

All stream and retention basin data collected during the 21 month period during which performance was monitored was placed on punched cards to permit analysis by use of a Burroughs B5500 computer. Prior to punching the data they were screened to remove any results which were obviously erroneous and to eliminate data collected during those times when the stage of Sugar Creek produced flooding of the basin. The digital computer was used to calculate monthly averages for all parameters and to compute correlation coefficients between selected variables.

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SECTION VII

RESULTS

Analysis and Limitations of Data

Data available for interpretation of the performance of the basin have been previously described and typical data sheets are shown as Appendices III and IV. Ideally, the performance of the basin could have been evaluated by tracing the passage of combined sewer overflow from individual storms through the retention basin. Unfortunately, this was not possible because no measure of influent flow rate was possible. Thus, the total amount of pollutant material (such as BOD, suspended solids, or coliform bacteria) contributed by a particular storm and the attenuation of these constituents in the basin could not be precisely determined.

In the absence of means for observing the effect of the retention basin on the overflow from individual storms, it was necessary, in interpreting the performance of the basin, to resort to analysis of the gross effect of the basin discharge on the receiving stream and on use of comparisons of influent and effluent concentrations without regard to flow rates. The error inherent in this approach was fully recognized; however, in the absence of influent flow measurements and intensive sampling of individual storms, analysis of the data in this way was the only method available for analysis of the data.

As described in the section on procedures, the arrangements made for sampling the basin's influent and effluent involved compositing flow over a period of 24 hrs. This had the effect of "blurring" the temporal changes caused by combined sewer overflow and only average daily values were available for analysis. Some determinations, such as influent and effluent dissolved oxygen and stream water quality parameters, were obtained from grab samples. These represented water quality from only one point in time and also precluded analysis of the timewise variation in water quality caused by storms and by performance of the basin.

Specifically, the method of data analysis was as follows. Correlation coefficients between various parameters were computed by use of a digital computer. Results from analysis of daily composites or grab samples were used for the determination of correlation coefficients and values were not used unless there was a corresponding value from the other parameter being considered in the correlation. A tabulation of correlation coefficients is included as Tables I and II. The other method of data analysis was to observe plots of the various variables as a function of time during the 20 months that basin performance was closely monitored. To eliminate the random variations from day to day, monthly average values were used for these comparisons.

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TABLE I

TABULATION OF CORRELATION COEFFICIENTS
RETENTION BASIN PERFORMANCE

Correlation of	With	Correlation Coefficient	Number of Observations
Rainfall	Influent BOD	0.03	345
"	Influent SS	0.12	352
"	Influent VSS	-0.13	324
"	Influent MBAS	0.13	194
"	Influent Coliform Density	0.02	260
"	Influent Fecal Coliform	-0.15	54
"	Influent Fecal Strep	-0.17	32
"	Effluent BOD	-0.03	347
"	Effluent SS	0.09	352
"	Effluent VSS	-0.04	319
"	Effluent Coliform Density	-0.02	261
"	Effluent Fecal Coliform	-0.20	53
"	Effluent Fecal Strep	-0.04	31
Sunshine	Influent Dissolved Oxygen	0.14	360
"	Influent pH	-0.03	361
"	Effluent SS	0.02	360
"	Effluent VSS	-0.01	356
"	Effluent Dissolved Oxygen	0.11	361
"	Effluent pH	0.02	361
"	Change in Dissolved Oxygen	0.01	359
Wind Velocity	Effluent SS	-0.01	361
Retention Time	Effluent BOD	0.05	296
"	Effluent SS	-0.05	296
"	Effluent VSS	-0.07	296
"	BOD Reduction	-0.05	286
"	SS Reduction	0.07	291
"	Coliform Reduction	-0.01	202
"	Fecal Coliform Reduction	0.24	45
"	Fecal Strep Reduction	-0.23	32
Influent BOD	Effluent BOD	0.30	348
"	Effluent DO	0.03	356
"	Dissolved Oxygen Change	0.20	353
Influent SS	Effluent SS	0.11	356
Influent DO	Effluent DO	0.53	354
Influent Coliform Density	Influent MBAS	-0.03	264
"	Influent Fecal Coliform	-0.09	54

TABLE I (continued)

Correlation of	With	Correlation Coefficient	Number of Observations
Influent Coliform Density	Influent Fecal Strep	0.73	32
"	Effluent Coliform Density	0.38	261
"	Coliform Reduction	0.07	260
Effluent Water Temperature	Effluent DO	0.36	360
"	BOD Reductions	-0.25	345
"	Coliform Reduction	-0.12	260
"	Fecal Coliform Reduction	-0.36	53
"	Fecal Strep Reduction	-0.18	32
Effluent pH	Effluent DO	0.40	356
Effluent Coliform Density	Effluent Fecal Coliform	0.62	53
"	Effluent Fecal Strep	0.85	32

TABLE II

TABULATION OF CORRELATION COEFFICIENTS SUGAR CREEK STUDIES

Correlation of	With	Correlation Coefficient	Number of Observations
Station 1 BOD	Station 2 BOD	0.08	347
"	Station 3 BOD	0.30	349
Station 1 SS	Station 2 SS	0.26	354
"	Station 3 SS	0.25	354
Station 1 VSS	Station 2 VSS	0.44	354
"	Station 3 VSS	0.37	354
Station 1 DO	Station 2 DO	0.81	356
"	Station 3 DO	0.74	350
Station 1 pH	Station 2 pH	0.40	350
"	Station 3 pH	0.30	356
Station 1 Coliform Density	Station 2 Coliform Density	0.16	261
"	Station 3 Coliform Density	0.09	260
Station 1 Fecal Coliform	Station 2 Fecal Coliform	0.22	52
"	Station 3 Fecal Coliform	-0.01	54
Station 1 Fecal Strep	Station 2 Fecal Strep	0.21	32
"	Station 3 Fecal Strep	0.35	32
Station 1 Water Temperature	Station 1 DO	-0.71	359
"	Station 1 Coliform Density	0.03	359
"	Station 1 Fecal Coliform	-0.24	57
"	Station 1 Fecal Strep	-0.01	32
"	Station 2 Water Temp.	0.96	357
"	Station 3 Water Temp.	0.92	357
Station 2 Water Temperature	Station 2 DO	-0.70	360
"	Station 2 Coliform Density	-0.06	360
"	Station 2 Fecal Coliform	-0.21	55
"	Station 2 Fecal Strep	-0.09	32
Station 3 Water Temperature	Station 3 DO	-0.62	358
"	Station 3 Coliform Density	-0.05	358
"	Station 3 Fecal Coliform	0.08	55
"	Station 3 Fecal Strep	0.06	32
Effluent BOD	Station 2 BOD	0.05	352
"	Station 3 BOD	0.02	352
Effluent SS	Station 2 SS	0.11	354
"	Station 3 SS	0.05	354
Effluent VSS	Station 2 VSS	0.00	353
"	Station 3 VSS	0.07	352

TABLE II (continued)

Correlation of	With	Correlation Coefficient	Number of Observations
Effluent DO	Station 2 DO	-0.12	356
"	Station 3 DO	-0.12	354
Effluent pH	Station 2 pH	0.07	356
"	Station 3 pH	0.05	356
Effluent Coliform Density	Station 2 Coliform Density	0.25	261
"	Station 3 Coliform Density	0.19	261
Effluent Fecal Coliform	Station 2 Fecal Coliform	0.38	53
"	Station 3 Fecal Coliform	0.22	53
Effluent Fecal Strep	Station 2 Fecal Strep	0.46	32
"	Station 3 Fecal Strep	0.11	32
Effluent Water Temperature	Station 2 Water Temp.	0.98	357

Quality and Quantity of Combined Sewer Overflows

Of interest in studies of combined sewer overflow are the influence of factors such as storm duration and intensity, storm pattern, and the nature of the drainage area on the quantity and quality of combined sewer overflow. Such evaluations could not be made in this study because no measure of the quantity of overflow was available and the arrangements made for sampling resulted in collection of composite samples rather than for a series of samples collected during the duration of a storm. However, an attempt to interpret the influence of rainfall on the nature of combined sewer overflow could be made by use of the composite data. These results are presented here. Again, it is recognized that the veracity of the conclusions is suspect because of the use of daily composite values and because of the lack of influent flow measuring capabilities.

From Table I it can be seen that a significant degree of correlation did not exist between rainfall and any of the influent water quality parameters. Even MBAS, which was selected as a possible indicator of the presence of wastes of household origin failed to show a high degree of correlation with rainfall.

It is considered that the poor correlation of influent water quality to the incidence of rainfall may be attributed to the nature of the influent sample. Combined sewer overflows of short duration would not significantly influence the quality of the composite sample because they would be diluted with other samples collected throughout the 24 hr compositing period. Of even more importance is the fact that the influent samples were simply collected at the entrance to the basin and, thus, merely represented basin contents at that location.

Basin Performance

Evaluations of basin performance such as could be determined by comparing the quality of the influent and effluent composite samples are included here. The analysis is based on use of correlation coefficients between variables and inspection of variations in monthly average values for various water quality parameters.

BOD Removal

The monthly average BOD of the influent and effluent during the period of this study is shown in Figure 21. It is seen that during most of the study the average effluent BOD was less than that of the influent. The influent BOD averaged 21.7 mg/l while the effluent averaged 15.9 mg/l. This represents a 27 percent BOD reduction.

It should be noted however that the basin could not be relied upon to reduce average BOD levels during all seasons of the year. During the

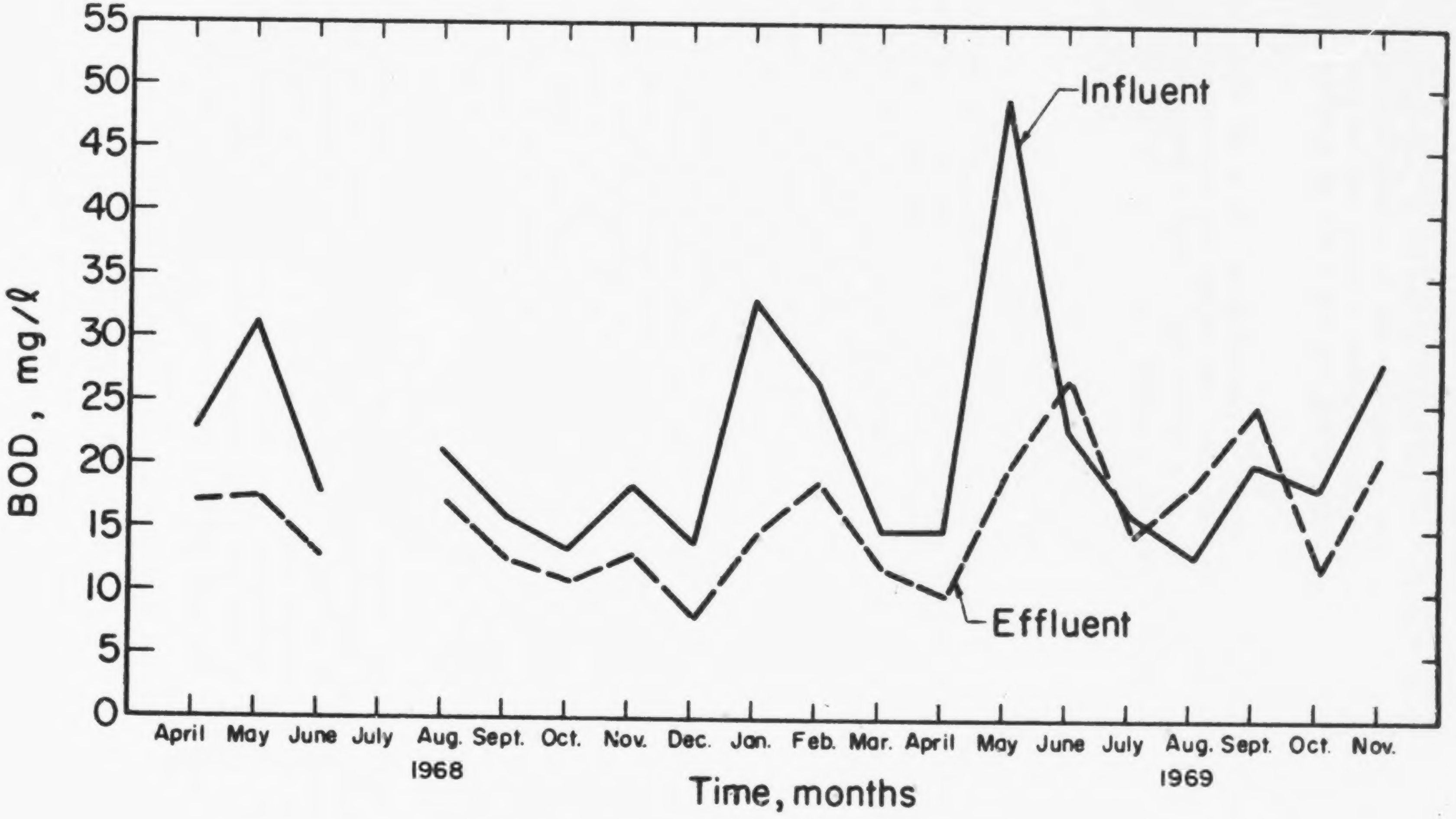


FIGURE 21. Monthly Average BOD Values of Basin Influent and Effluent

period from June until October, 1969, the effluent BOD equaled or exceeded that of the influent. This was caused by production of algae in the basin through photosynthetic activity. The resulting effluent BOD was higher than that of the influent in spite of any sedimentation of suspended BOD or of any BOD reduction due to biological degradation. The period during which algal photosynthesis resulted in a net production of BOD in the lagoon corresponded to the time of maximum radiant energy.

From Table I it may be seen that no correlation could be shown between the average basin retention time and the resulting effluent BOD. An indicated correlation was found between the influent BOD and the effluent BOD and between water temperature and the resulting BOD reduction.

Dissolved Oxygen Levels

Basin influent and effluent dissolved oxygen levels are shown in Figure 22. It is seen that the variation in the dissolved oxygen content of the effluent did not reflect the change in dissolved oxygen saturation with temperature during the year. To illustrate, the saturation concentration varied from a low of 8.1 (in July) to a high of 13.8 (in January). Much of the time during summer months, the effluent was supersaturated with oxygen. This reflects the photosynthetic production of oxygen by algae and verifies the increase in effluent BOD during summer months noted in the previous section. Photosynthetic activity was less during the winter; during severe cold periods, the basin was covered with ice. However, flows received during periods of ice cover traveled under the ice and discharged to the receiving stream. Figure 22 shows that the influent dissolved oxygen concentration tended during most months to parallel the effluent concentration (the correlation coefficient between the two was 0.53). It is believed that this reflects the fact that the influent dissolved oxygen sample was obtained at the entrance of the basin and, during periods of low flow, the contents there differed little from those at the point of discharge from the basin.

The correlation coefficient between dissolved oxygen and percent possible sunshine was surprisingly low (0.11). However, it is considered that if the measure of total radiant energy had been available instead of a measure of percent possible sunshine, a much higher correlation coefficient would have been obtained. A better correlation was obtained with effluent pH and effluent dissolved oxygen (0.40). This was expected inasmuch as both pH and dissolved oxygen are increased by algal activity.

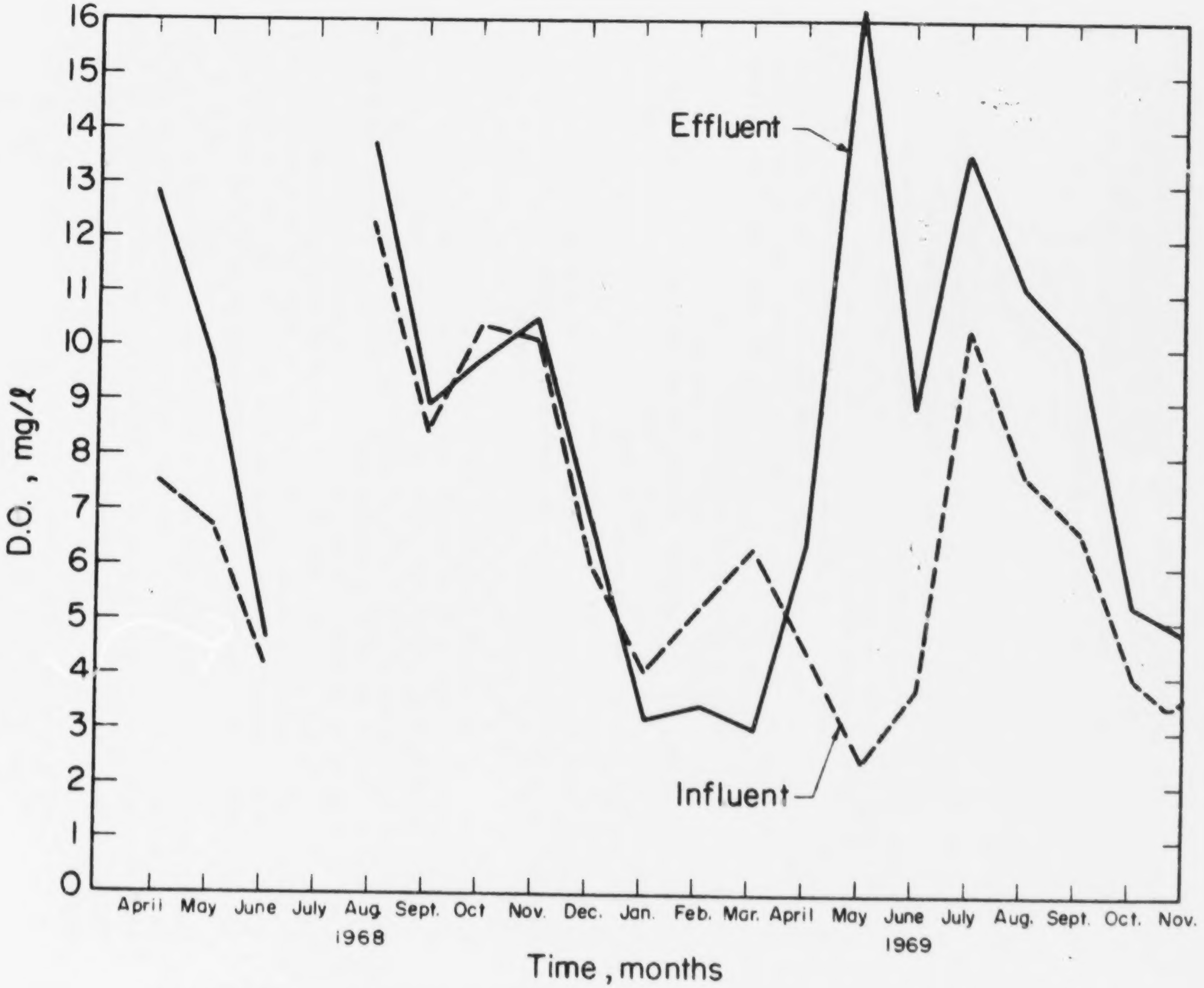


FIGURE 22. Variation of Dissolved Oxygen in Basin Influent and Effluent

pH

Figure 23 shows the average monthly pH of the basin influent and effluent. Arithmetic averages were computed for convenience and hence the data do not precisely reflect the hydrogen ion concentration, but they do show trends. It is seen that the effluent pH consistently exceeded that of the influent. The difference was greatest during summer months when algal activity was greatest.

Suspended Solids

Figure 24 shows the variation of influent and effluent suspended solids during the period of monitoring the performance of the basin. It is seen that the effluent suspended solids concentration tended to remain in the range of about 20 to 40 mg/l regardless of the influent suspended solids concentration except during summer months when high algal densities in the effluent caused much higher concentrations. In reviewing Figure 24, it may be noted that a high concentration of suspended solids occurred in the influent during January and June 1969. On two different occasions during the month of January 1969, the Cook Street Pumping Station was taken out of operation for repairs. This occurred on January 16 and 17, and again on January 28 through 31. During these periods of dry weather flow, raw wastewater was discharged to the retention basin. This probably accounts for the high concentration of suspended solids recorded in the influent for January 1969. In June 1969, it was necessary to remove the solids which had accumulated in the influent sampling line. This operation probably resulted in samples having an unusual amount of suspended solids, not truly representative of the concentration entering the basin.

From Table I it is seen that there was not a high degree of correlation of the effluent suspended solids concentration or the amount of reduction in suspended solids concentration with any other operating variables, including retention time. It must be remembered that the calculations are based on daily averages and if individual storms could have been studied more carefully some relationship might have been observed. Again, it is suspected that the lack of correlation between sunshine and effluent suspended solids concentration is due to the fact that the actual radiant energy was not measured but rather a percent of possible sunshine was used in calculating the correlation of coefficients.

The volatile content of the influent and effluent suspended solids is illustrated in Figure 25. The effluent was consistently more volatile than the influent. This reflects the selective sedimentation of nonvolatile material and/or the synthesis of volatile material in the basin.

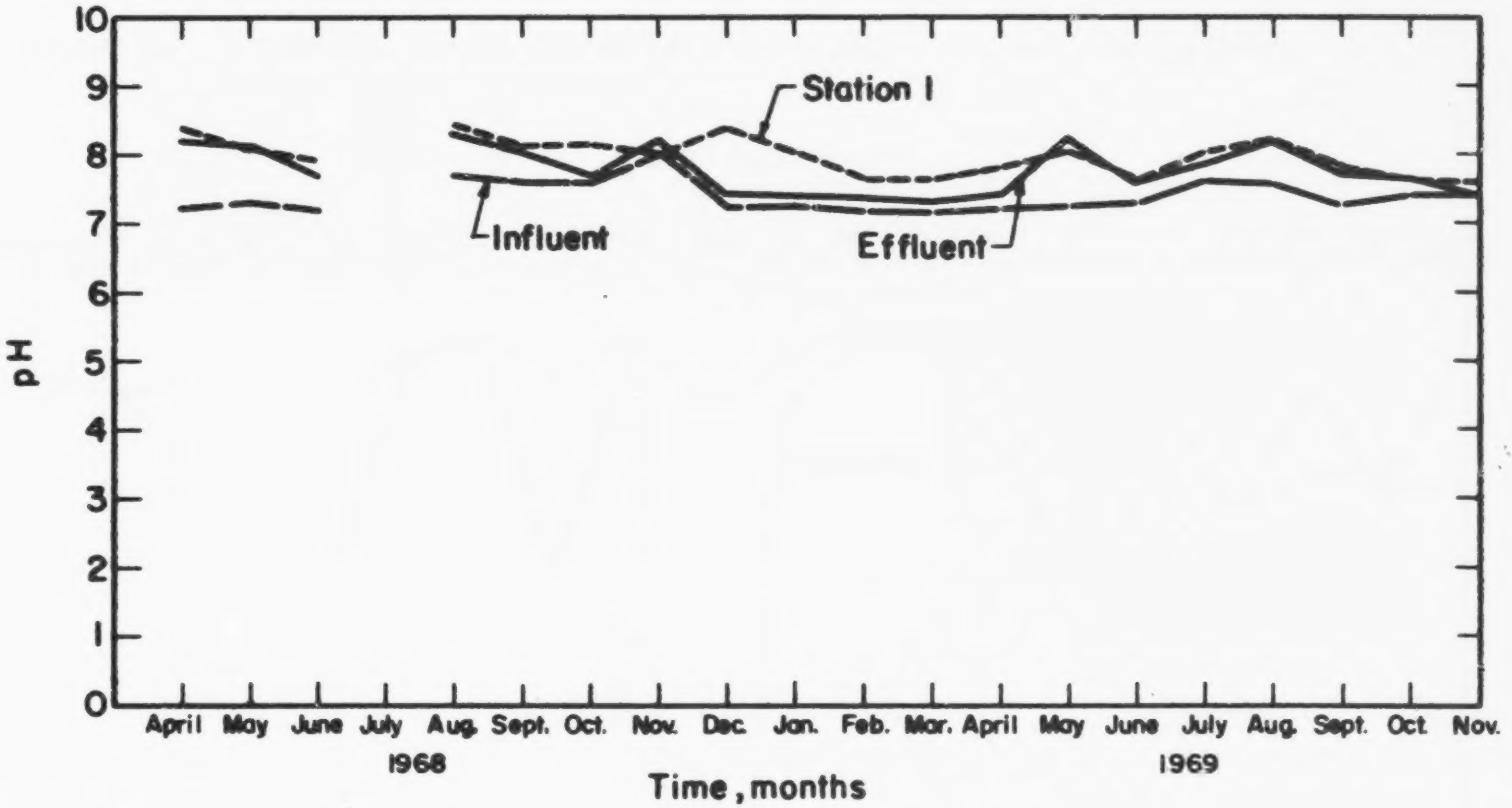


FIGURE 23. pH Levels in Basin Influent, Basin Effluent and in Stream Above Basin

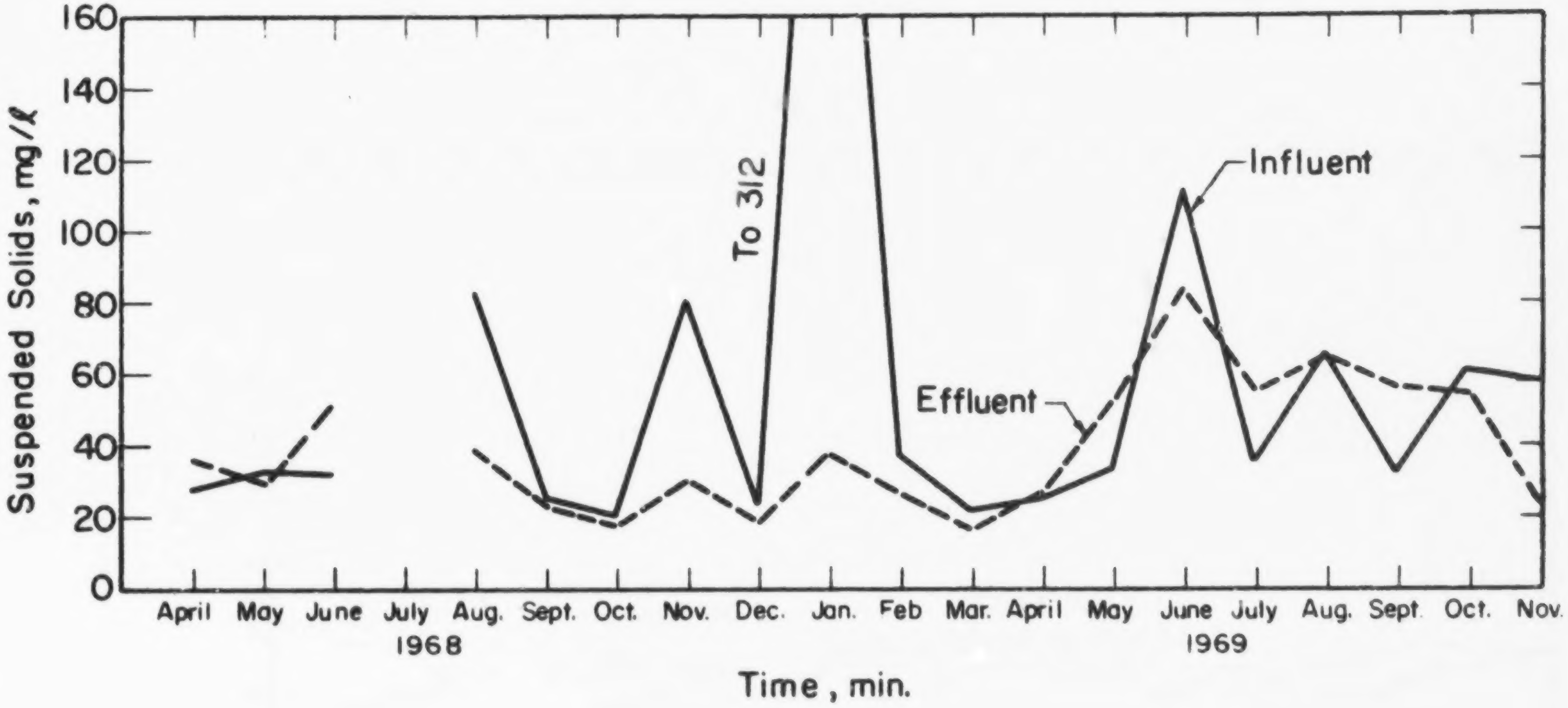


FIGURE 24. Suspended Solids Concentrations in Basin Influent and Effluent

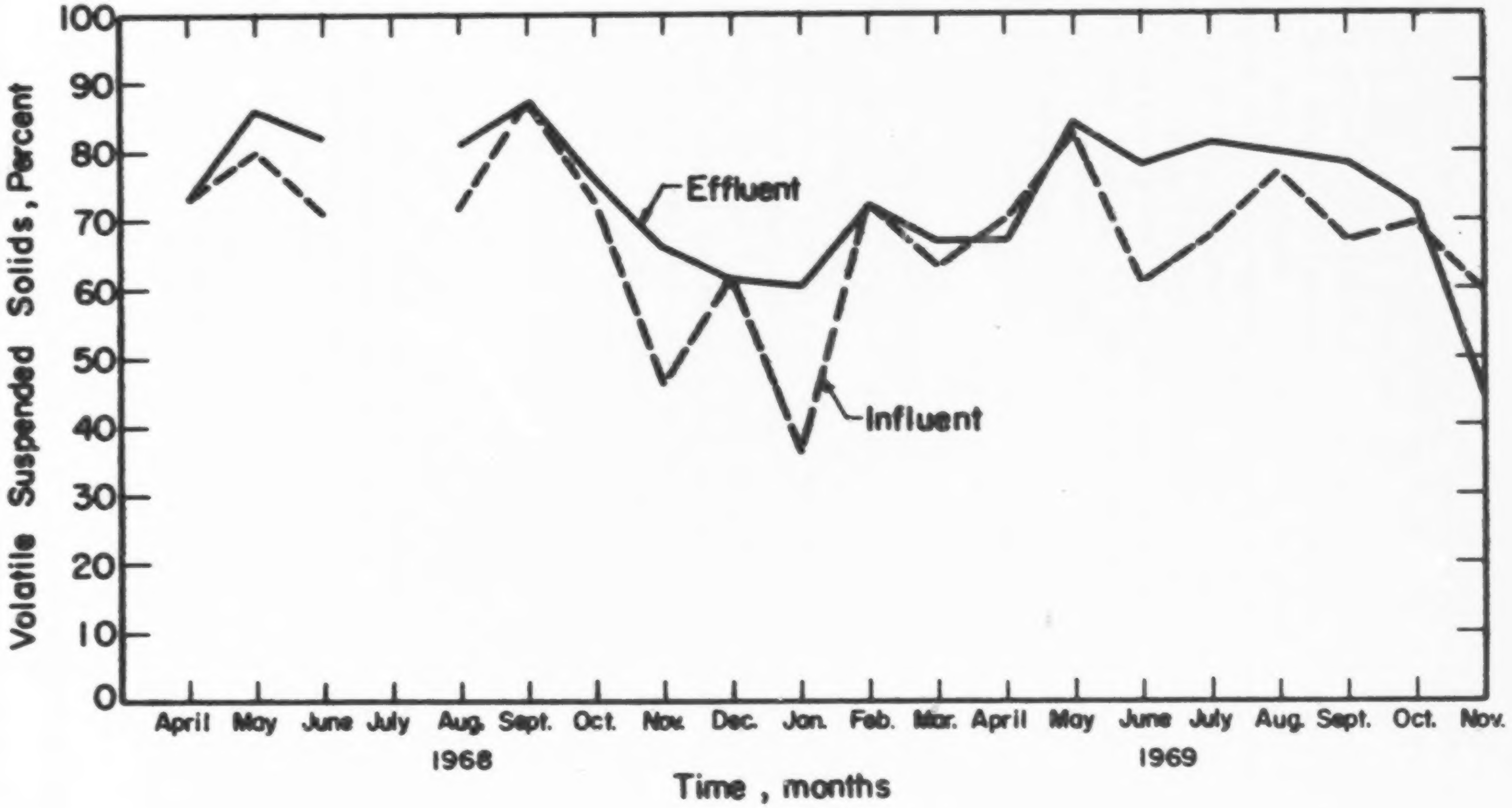


FIGURE 25. Volatile Content of Solids in Basin Influent and Effluent

Nutrients

Subsequent to initiating the study to evaluate the performance of the basin it was decided that information regarding the amount of nitrogen and phosphorus entering and leaving the basin would be useful in discerning the value of the basin. In the case of nitrogen, it was proposed to determine the concentration of organic, ammonia, and oxidized (nitrite and nitrate) nitrogen. Such information would not only have provided data on the effect of the basin in changing the total amount of nitrogen discharged to the receiving stream but also would have indicated the transformations taking place. Consideration was also to be given to determine the distribution of the different forms of nitrogen between the benthic deposits and the overlaying water, taking into account that associated with suspended matter (algae) and in solution. During the fall of 1968, this aspect of the study was initiated. Because of limited analytical capability, it was not possible to continue the determinations. Consequently, the limited amount of nitrogen data does not warrant inclusion in the report.

Phosphorus analyses were made on the daily composited influent and effluent samples collected during the period April through November 1969. The samples were analyzed for total inorganic phosphorus and orthophosphate; meta or poly phosphate was determined by the difference. Table III summarizes the results. It would appear that the results are typical of municipal combined sewer overflow. On a monthly basis, the concentration of total inorganic phosphorus ranged from 0.73 to 1.99 mg/l as P in the influent, while that in the effluent ranged from 0.55 to 1.80 mg/l as P. In general, there was a slight reduction in total inorganic phosphorus through the basin. This may have occurred because of conversion of inorganic forms to an organic form, e.g. algae synthesis, or because of precipitation and/or sedimentation in the basin.

It was intended to make a more detailed study of the basin with respect to its effect on total phosphorus and the distribution of the different forms (including organic) between the influent and effluent and in the basin itself. Unfortunately, the data are most incomplete in fulfilling this objective. Further, using the limited data available, it is not possible to formulate any definite conclusions even though a number of correlations were considered. For example, there was no relationship between the concentration of phosphorus in the influent on a daily basis and rainfall or flow to the basin.

Indicator Organisms

Figure 26 shows the consistent reduction in coliform organisms which was observed to occur in the lagoon. During the period of the study, the reduction averaged 72 percent. However, it should be remembered that the influent coliform density was high (averaging 1,250,000/100 ml) and thus the effluent coliform density was significant (353,000/100 ml)

TABLE III

TOTAL INORGANIC, ORTHO, AND META PHOSPHATES IN INFLUENT AND EFFLUENT OF RETENTION BASIN

Month	No. Samples	Influent (mg/l as P)			Effluent (mg/l as P)		
(1969)	in Month	Ortho	Meta	Total	Ortho	Meta	Total
April	18	1.09	0.48	1.54	0.96	0.35	1.35
May	19	0.79	1.04	1.83	0.74	0.13	0.86
June	17	0.58	0.27	0.87	0.51	0.26	0.77
July	14	0.55	0.23	0.73	0.48	0.06	0.55
August	15	0.58	0.23	0.73	0.38	0.23	0.55
September	19	0.80	1.03	1.76	0.55	0.27	0.90
October	23	1.32	0.67	1.99	1.09	0.71	1.80
November	19	0.90	0.61	1.57	1.12	0.67	1.80

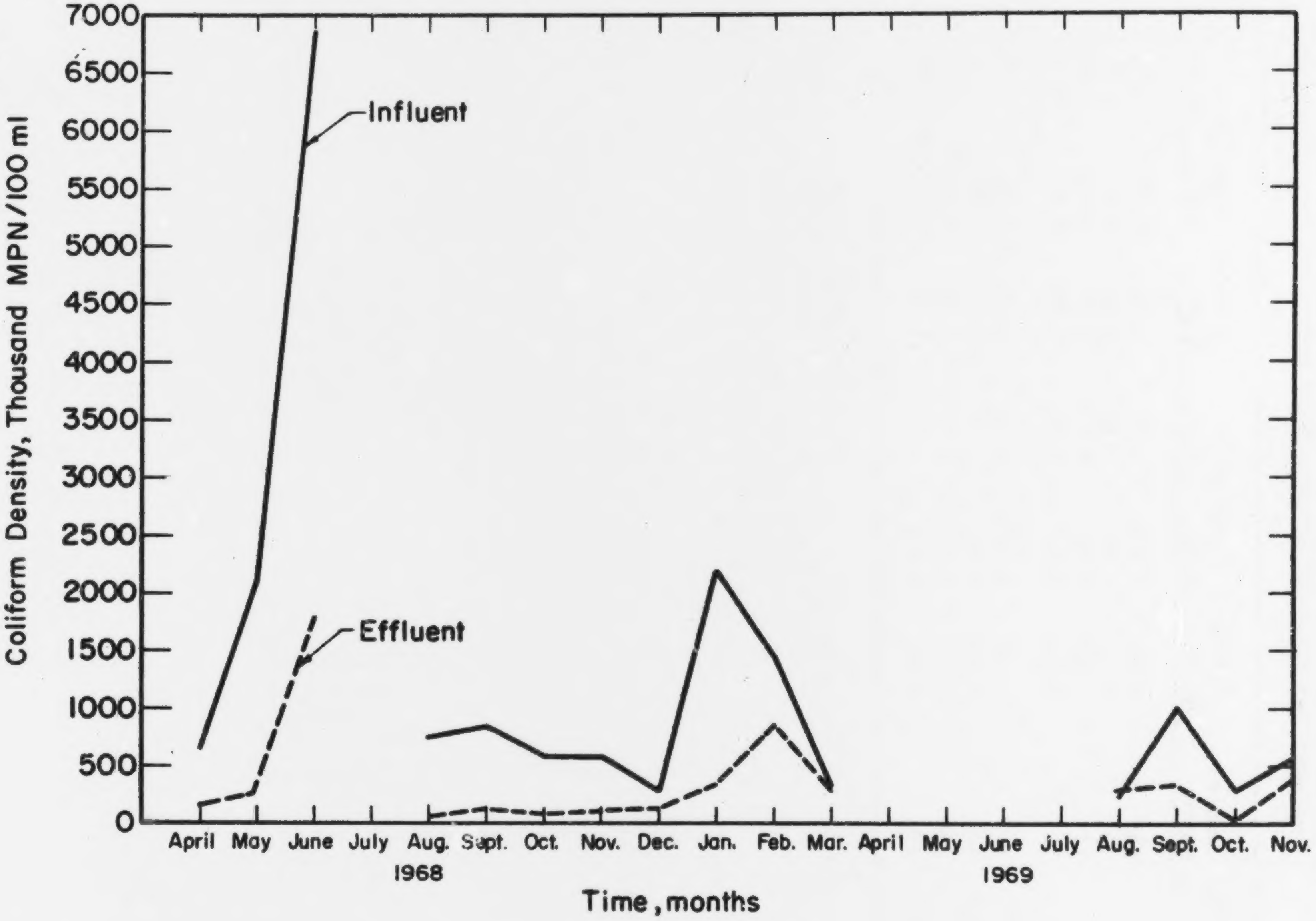


FIGURE 26. Reduction of Coliform Organisms in the Retention Basin

in spite of the high percentage reduction. No significant relationship existed between the lagoon retention time and coliform reduction. It may be noted that the average coliform density was exceptionally high in June 1968 in the influent and somewhat higher in the effluent. During June, Sugar Creek was flooded between June 1 and 12, causing the creek flow to backup into the basin. Also, because of a mechanical failure at the Cook Street Pumping Station and various sewer maintenance problems, the flow normally handled by the pumping station was bypassed to the basin during the period June 10 to 27. Thus, a substantial amount of raw wastewater was entering the basin along with any storm flow. This probably explains the high coliform densities reported in June 1968. The temporal variation in average basin retention time is shown in Figure 27. It must be remembered that this does not represent the retention time following individual storms. Figure 27 shows a greater retention time in the basin in November 1969 as compared to November 1968. This can be explained by considering the total rainfall in the two months, 1.38 in. in November 1969 as opposed to 3.93 in. in November 1968. For all indicator organisms, a negative correlation existed between basin temperature and reduction in microorganisms.

Significantly fewer data were collected for fecal coliforms and fecal streptococci and, for this reason, no plots of these data are presented. As with the coliform group there was a tendency for a reduction of these indicators in passage through the lagoon. The tabulation of correlation coefficients suggests a greater correlation between the coliforms and fecal streps than between coliforms and fecal coliforms.

Solids Accumulation

Measures of solids accumulation on the basin bottom obtained periodically throughout the study afforded some indication of the amount of sludge accumulation to be expected in a retention basin of the type used at Springfield. No profiles of solids concentration were obtained and hence calculation of the weight of solids accumulated in the basin at any time is not possible.

Solids at the basin bottom increase with sedimentation of influent suspended solids and by sedimentation of algae and bacteria synthesized in the basin. Solids depth in the basin bottom decreases because of compaction and because of solubilizing of decomposable organic material under anaerobic conditions with release of soluble BOD to the overlying liquid.

Solids profiles obtained during the study are presented as Figures 28, 29, and 30. The tendency for solids to settle in the vicinity of the basin entrance is apparent as is the progression of deeper sludge depths throughout the basin with time. Tabulation of total sludge accumulations after various periods of time as given by Figures 28, 29, and 30 is presented in Table IV.

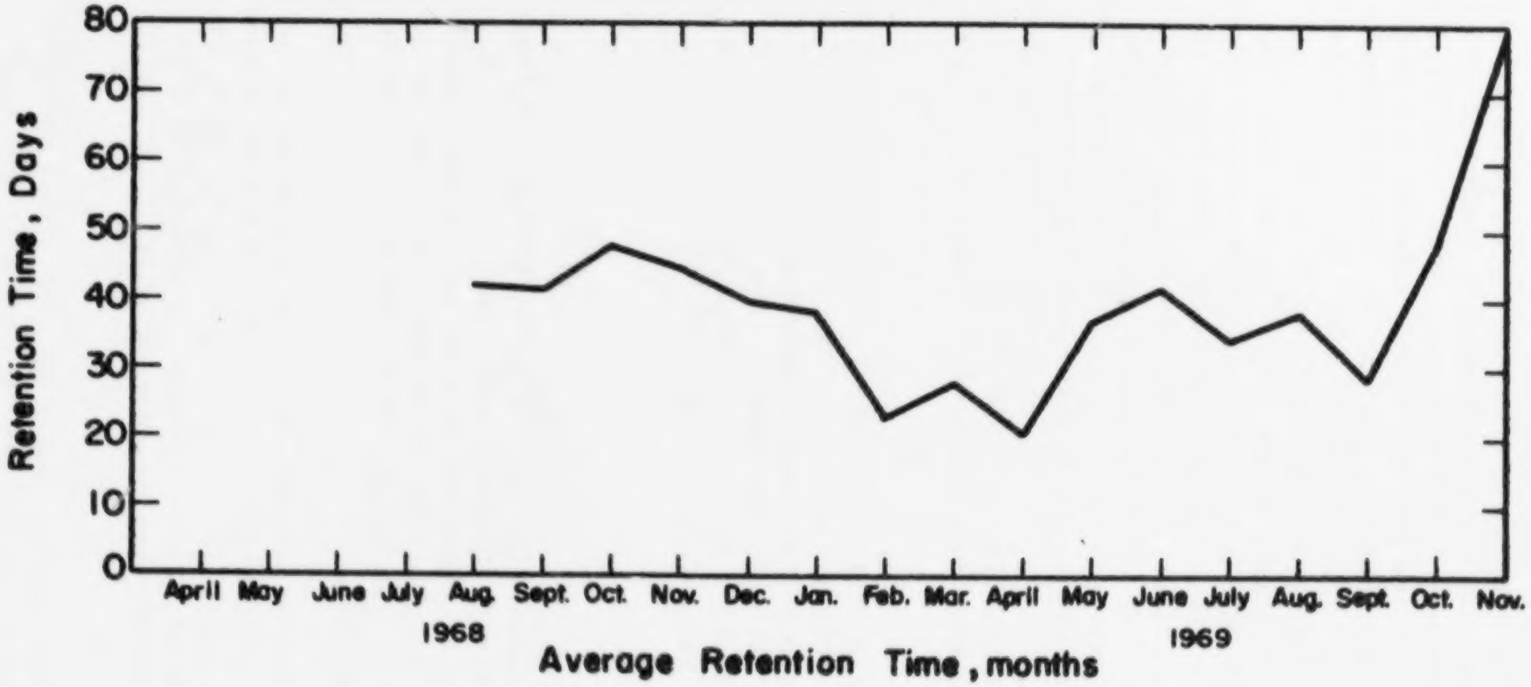
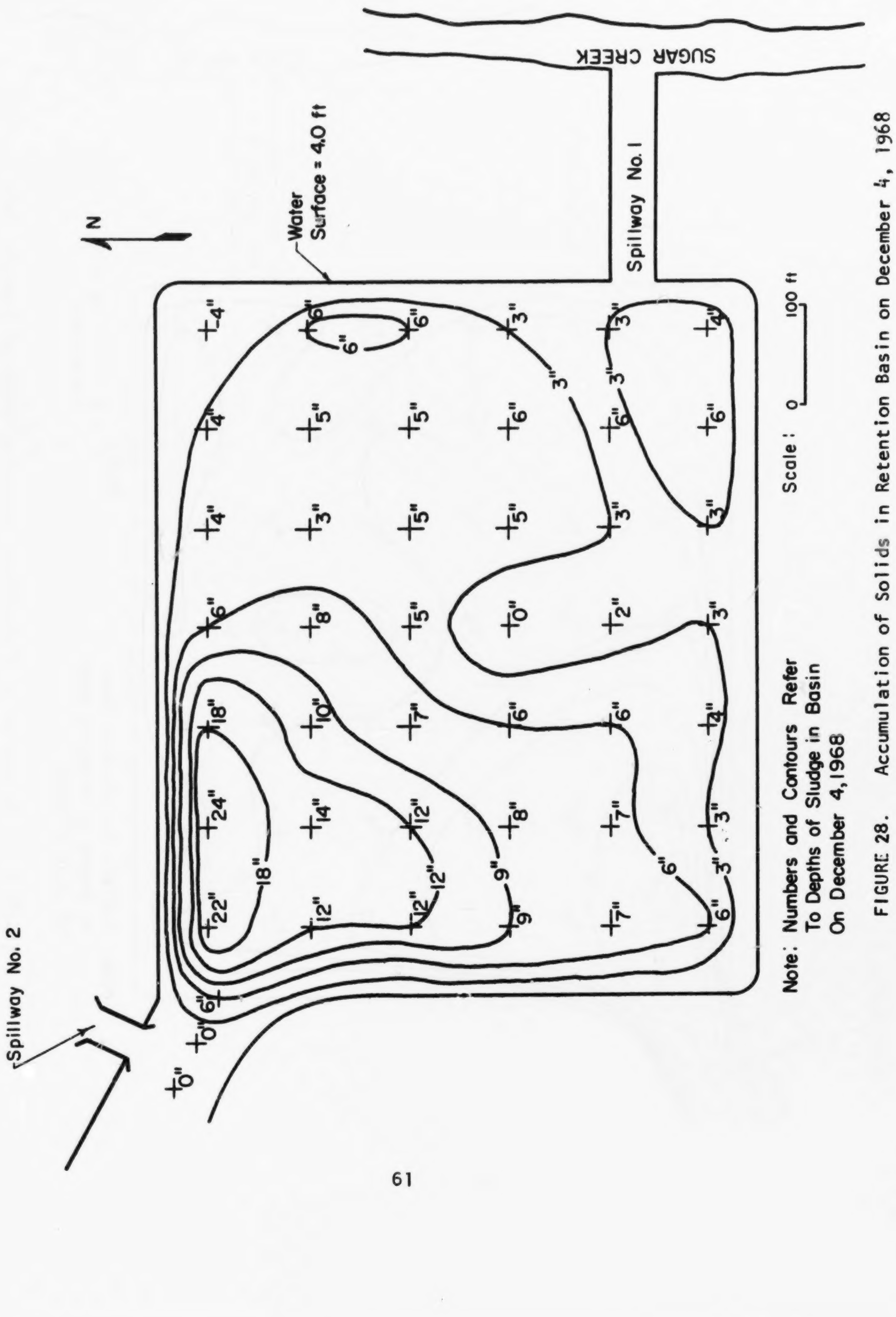
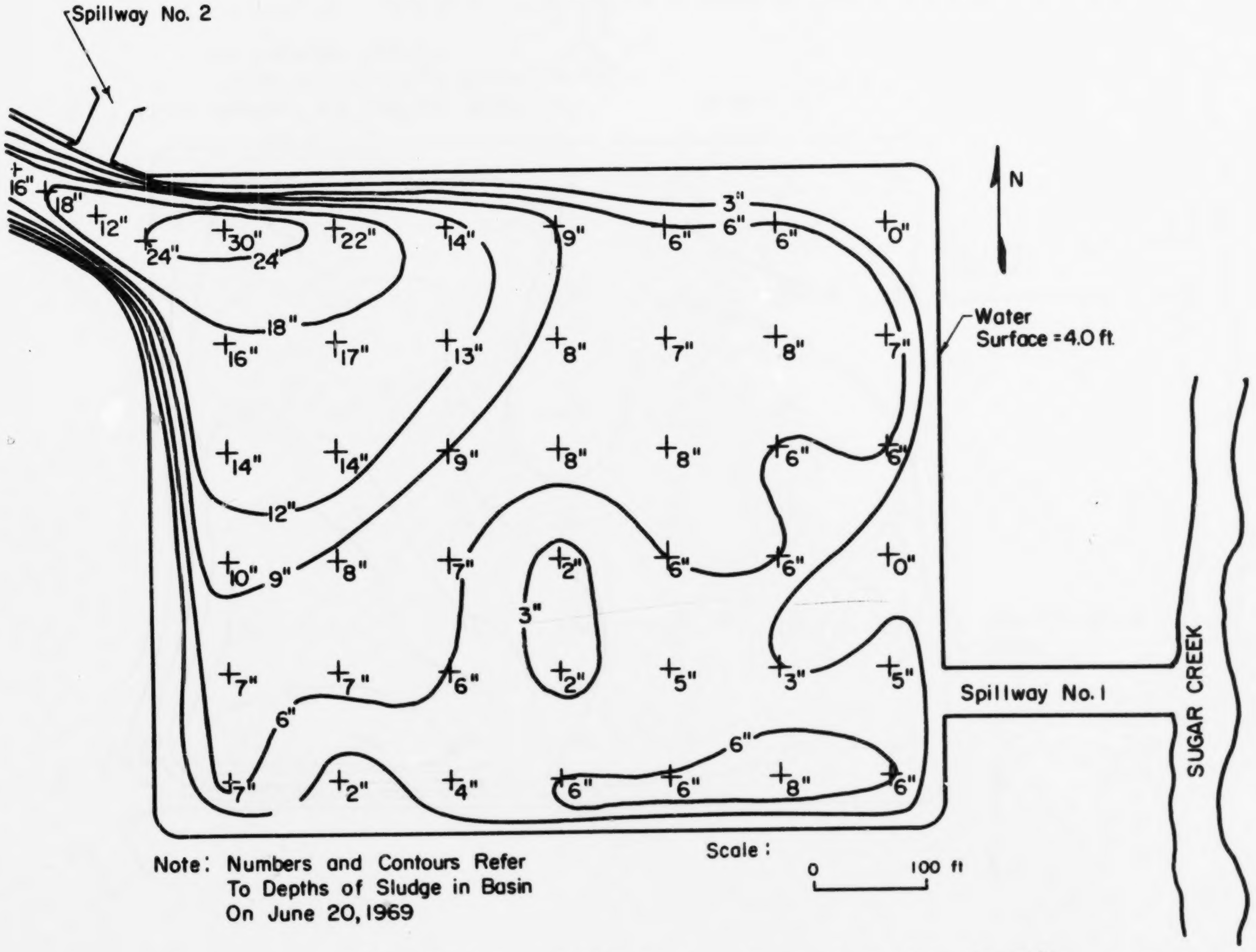


FIGURE 27. Average Retention Time in Basin


Spillway No. 2
N
Water Surface = 4.0 ft
Spillway No. 1
SUGAR CREEK
Scale: 0 100 ft
4"
4"
4"
6"
18"
24"
22"
6"
0"
0"
6"
6"
6"
5"
3"
8"
10"
14"
18"
12"
6"
5"
5"
5"
7"
12"
12"
12"
12"
3"
3"
6"
5"
0"
6"
8"
9"
9"
9"
3"
3"
6"
3"
2"
6"
7"
6"
7"
3"
4"
6"
3"
3"
4"
3"
3"
6"

Note: Numbers and Contours Refer
To Depths of Sludge in Basin
On December 4, 1968

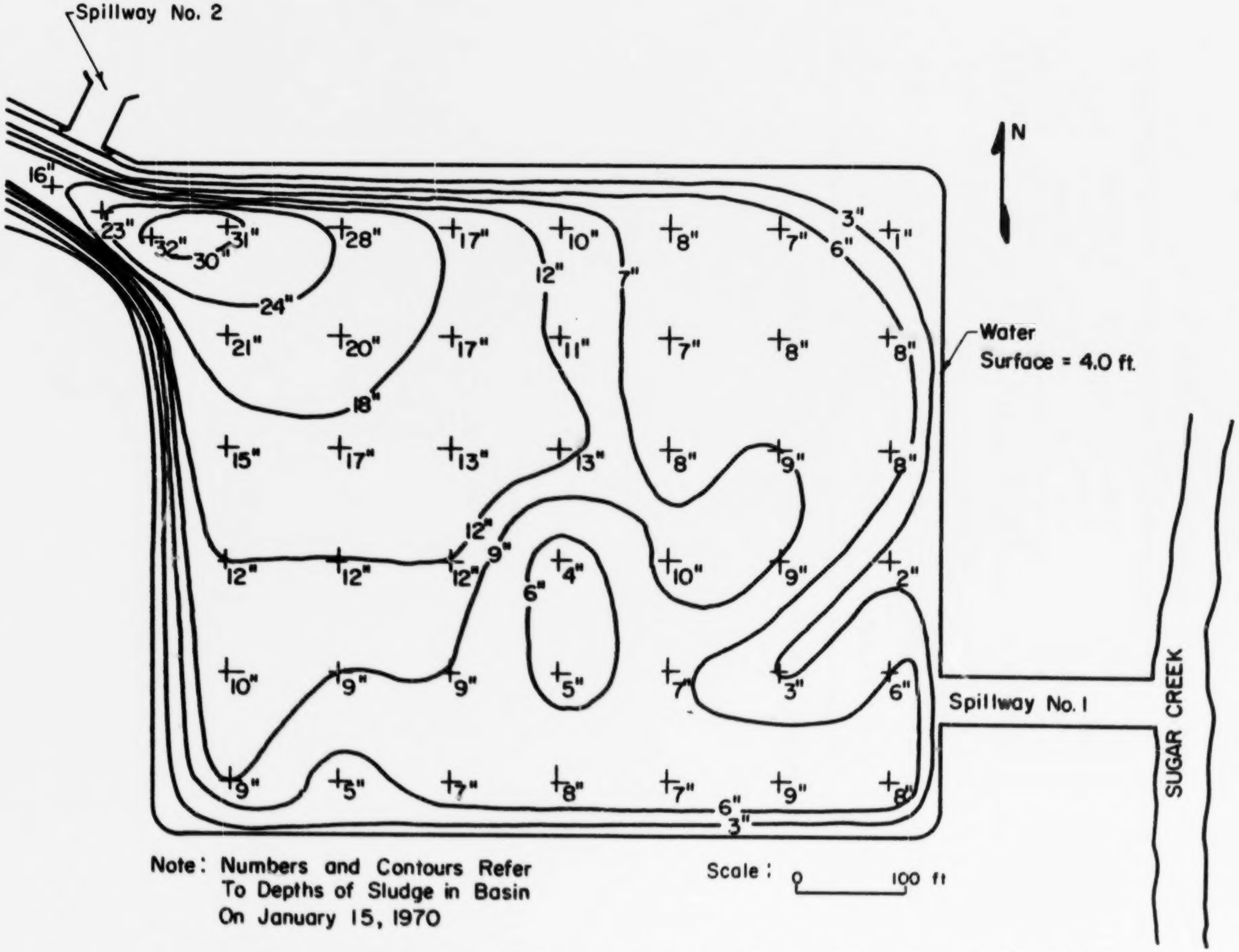
FIGURE 28. Accumulation of Solids in Retention Basin on December 4, 1968



Spillway No. 2
Spillway No. 1
SUGAR CREEK
N
Water Surface = 4.0 ft.
16"
18"
12"
24"
30"
24"
22"
14"
9"
6"
3"
6"
6"
0"
18"
16"
17"
13"
8"
7"
8"
7"
14"
14"
9"
8"
8"
6"
6"
12"
10"
9"
8"
7"
2"
6"
6"
0"
3"
7"
7"
6"
2"
5"
3"
5"
6"
7"
2"
4"
6"
6"
6"
8"
6"
Scale:
0
100 ft

Note: Numbers and Contours Refer
To Depths of Sludge in Basin
On June 20, 1969

FIGURE 29. Accumulation of Solids in Retention Basin on June 20, 1969


Spillway No. 2
N
Water Surface = 4.0 ft.
Spillway No. 1
SUGAR CREEK
Scale: 0 100 ft
16"
23" 32" 30" 31" 28" 17" 10" 8" 7" 3" 6" 1"
24" 12" 7"
21" 20" 17" 11" 7" 8" 8"
18"
15" 17" 13" 13" 8" 9" 8"
12"
12" 12" 12" 9" 6" 4" 10" 9" 2"
10" 9" 9" 5" 7" 3" 6"
9" 5" 7" 8" 7" 6" 9" 8"
3"

Note: Numbers and Contours Refer To Depths of Sludge in Basin On January 15, 1970

FIGURE 30. Accumulation of Solids in Retention Basin on January 15, 1970

TABLE IV

ACCUMULATION OF SOLIDS IN RETENTION BASIN

Date	Ave. Sludge Depth (in.)	Total Accum. (cu yd)	Time Basin in Operation (months)	Rate of Deposition (cu yd/yr)	*Fraction of Basin Volume Occupied (%)	*Rate of Filling (%/yr)
12/4/68	6.6	8500	14	7400	12.7	10.9
6/20/69	8.3	11,100	20.5	6500	16.5	9.7
1/15/70	10.8	14,400	27.5	6300	21.5	9.4

*Based on volume to bottom of notch in No. 1 spillway

The table shows that the rate of solids accumulation diminished with time. This could be anticipated because greater total amounts of decomposition and consolidation occur as the volume of accumulated sludge increases. However, the rate of sludge deposition will always exceed the rate of sludge destruction because of the nondecomposable solids contained in the basin influent and because of the fact that part of the solids synthesized within the basin are biologically stable. Thus, it is clear that it will be necessary to remove solids from the basin at some time. The data are not adequate to permit estimation of the required cleaning frequency. However, it seems safe to conclude that solids accumulation would significantly interfere with effective performance of the basin within 5 to 10 years. In design of facilities of this type, attention needs to be given to the basin volume required for solids storage. Perhaps multiple cells should be provided to permit drainage of individual cells without interrupting operation of the entire facility.

Stream Studies

Inasmuch as the study was prompted by the severe water quality deterioration problems which existed in the short reach of Sugar Creek above its confluence with the South Fork of the Sangamon River during periods of combined sewer overflow from the Cook Street Station, it was particularly appropriate that the influence of basin operation on the stream be monitored. Some limited data were available on the characteristics of the stream prior to construction of the basin (see Appendices I and II) and extensive data on stream quality above and below the point of the retention basin discharge were collected during this study. Most of the data were the result of routine daily samplings to ascertain stream water quality and, in addition, extensive special biological studies were conducted. These results are presented here.

Water Quality Investigations

At the time of this investigation, the Sanitary Water Board (SWB) of the State of Illinois was responsible for the establishment of water quality standards for receiving streams. The water quality of Sugar Creek, which receives the effluent from the retention basin, is covered by publication SWB-14 which deals with intrastate water exclusive of the interstate waters approved March 5, 1967. During the investigational period covered by this report, stream water quality data were obtained on the same frequency as the retention basin data and were analyzed in the same fashion. The data were collected from Station 1 located 7000 ft above the point of basin discharge and Stations 2 and 3 located 5500 and 14,500 ft, respectively, below the point of basin discharge.

BOD - Figure 31 shows the average monthly BOD at the three stream stations. It is seen that, on the average, BOD was lowest at Station 1 above the point of basin discharge and that an increase in stream BOD could be attributed to the basin and that further reduction in BOD occurred between Stations 2 and 3. However, with a few exceptions, the total variation in BOD between the three stations was less than 1 to 2 mg/l.

Dissolved oxygen - The average monthly dissolved oxygen concentration at the three stream stations is shown in Figure 32. It is apparent that the dissolved oxygen at all three stations follows the cyclic variation attributable to temperature variation and that the lowest levels occur during the warmest months of the year. The influence of the combined sewer overflow on the stream's dissolved oxygen concentration seems to be relatively insignificant although on the average the dissolved oxygen is highest above the basin, the effect of the basin discharge is apparent at Station 2, and a further reduction of dissolved oxygen occurs by the time the flow reaches Station 3. During only one month of the study period did the average monthly dissolved oxygen concentration at any station fall below 5 mg/l. This was during August 1969 and then only about 0.5 mg/l of the oxygen depletion could be attributed to the basin discharge. From the tabulation of correlation coefficients in Table II, it is seen that the dissolved oxygen concentration at the downstream stations correlated well with the dissolved oxygen concentration at Station 1 but was influenced little by the dissolved oxygen content of the retention basin discharge.

Suspended solids - The monthly average suspended solids concentrations in the receiving stream are shown in Figure 33. It is seen that the concentration of suspended solids in the stream above the point of retention basin discharge consistently exceeded the concentration in the effluent from the basin and that reduction in suspended solids occurred below the basin. The high concentration in the stream above the basin can perhaps be attributed to the discharge of solids from the water treatment plant.

pH - Figure 23 shows the comparison of the pH of the stream above the plant discharge with the pH of the retention basin effluent. It is seen that in spite of the intensive algal activity in the basin during the certain periods of the year the effluent pH did not differ considerably from that of the stream above the basin.

Temperature - A comparison of the temperature of the retention basin discharge and the stream above the point of discharge is shown in Figure 34. It is seen that the temperature of both flows is established by the ambient temperature. The retention basin discharge had no significant effect on the stream temperature.

Indicator organisms - The influence of the retention basin discharge on the coliform density in the stream is illustrated in Figure 35. It is

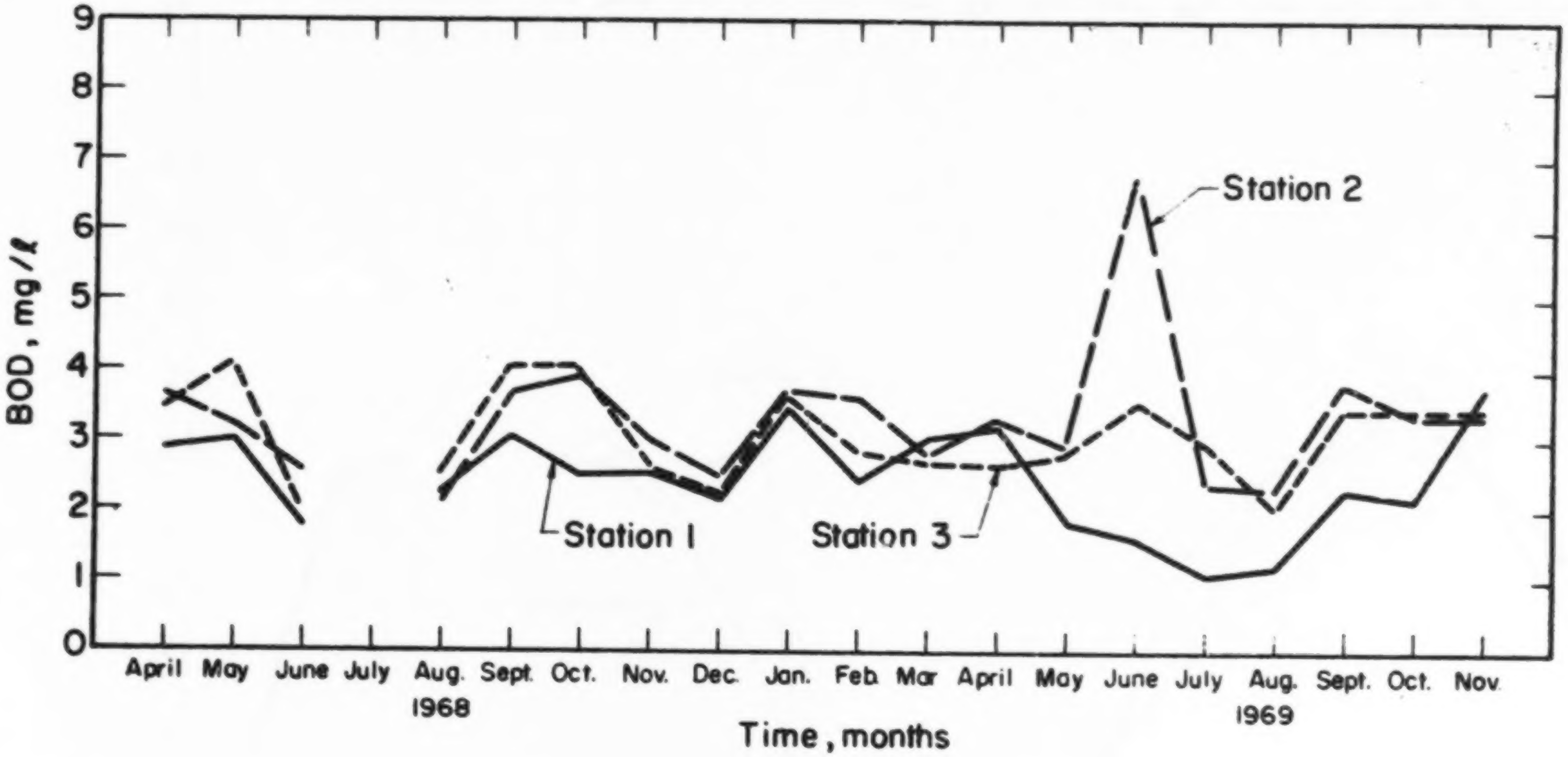


FIGURE 31. Average BOD in Stream Above and Below Point of Basin Discharge

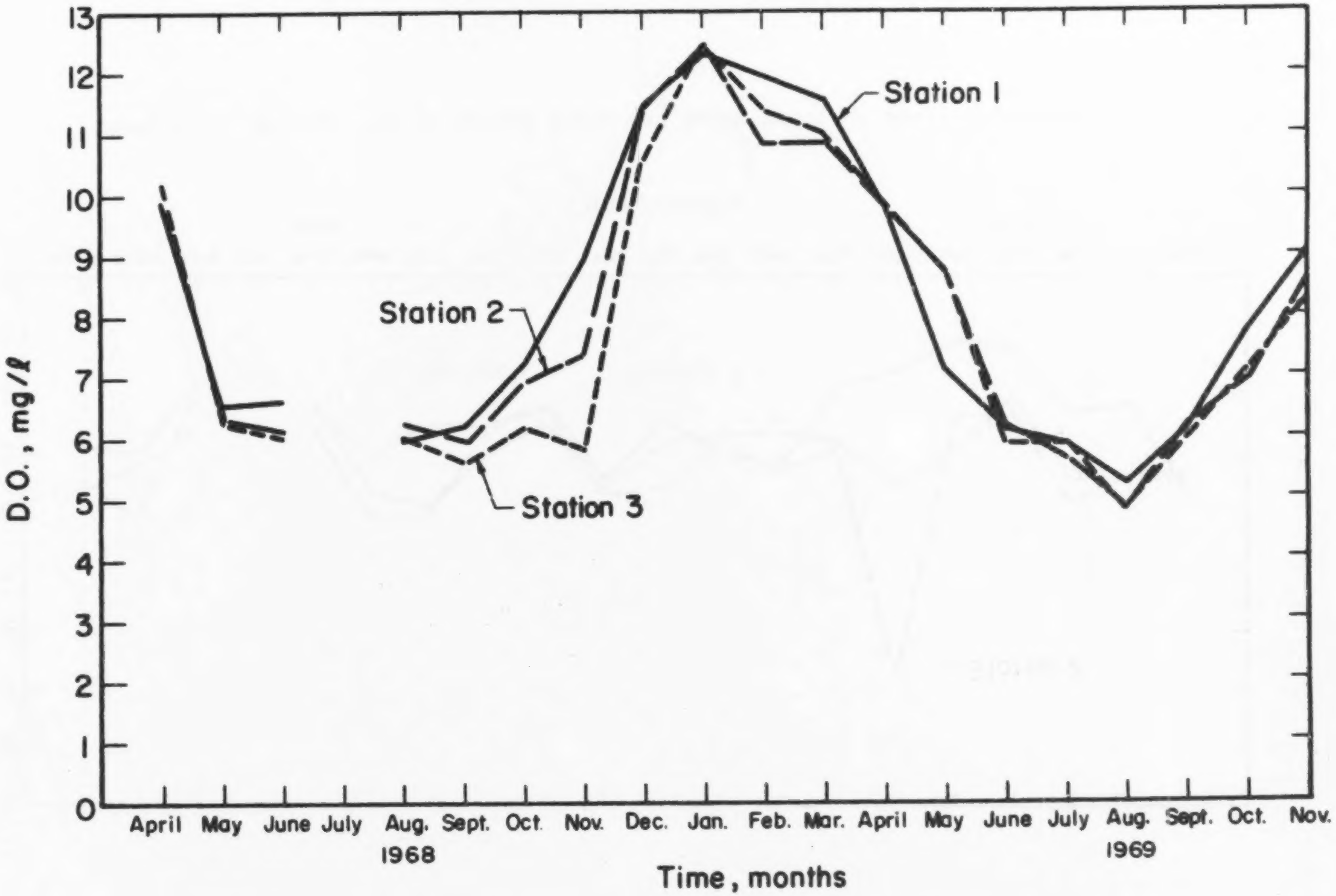


FIGURE 32. Effect of Retention Basin Discharge on Dissolved Oxygen Levels in the Receiving Stream

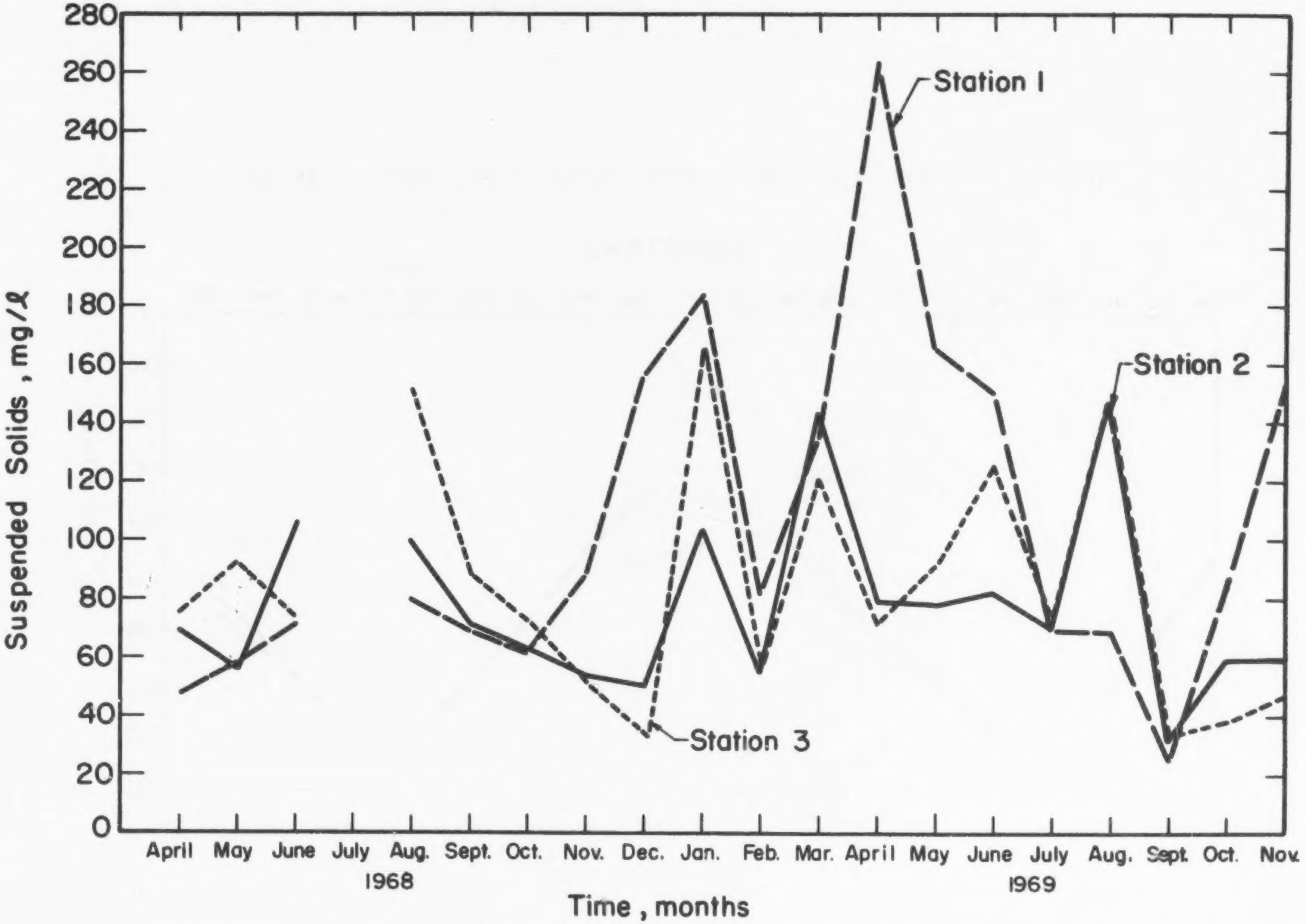


FIGURE 33. Suspended Solids Concentrations in Receiving Stream

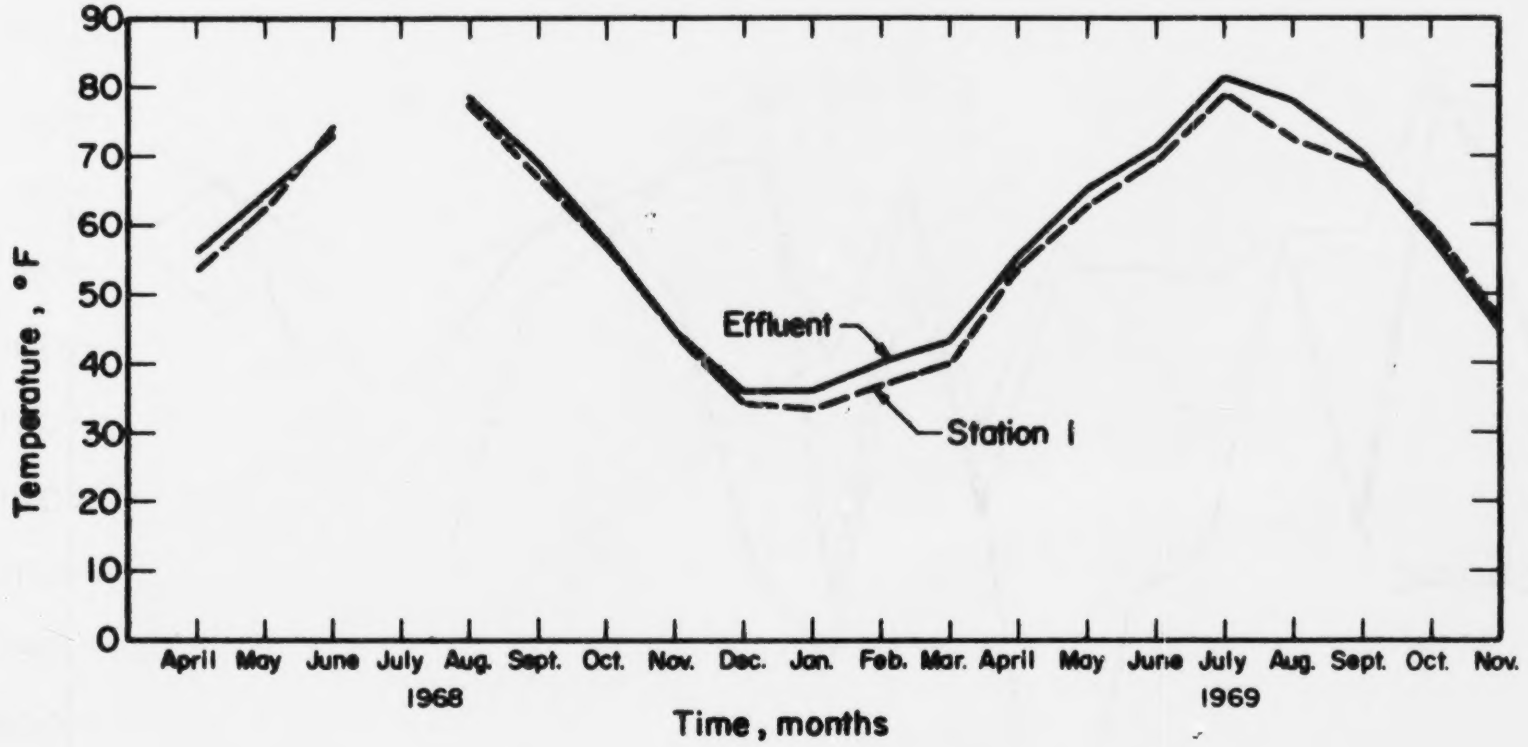


FIGURE 34. Comparison of Temperature of Basin Discharge and Receiving Stream

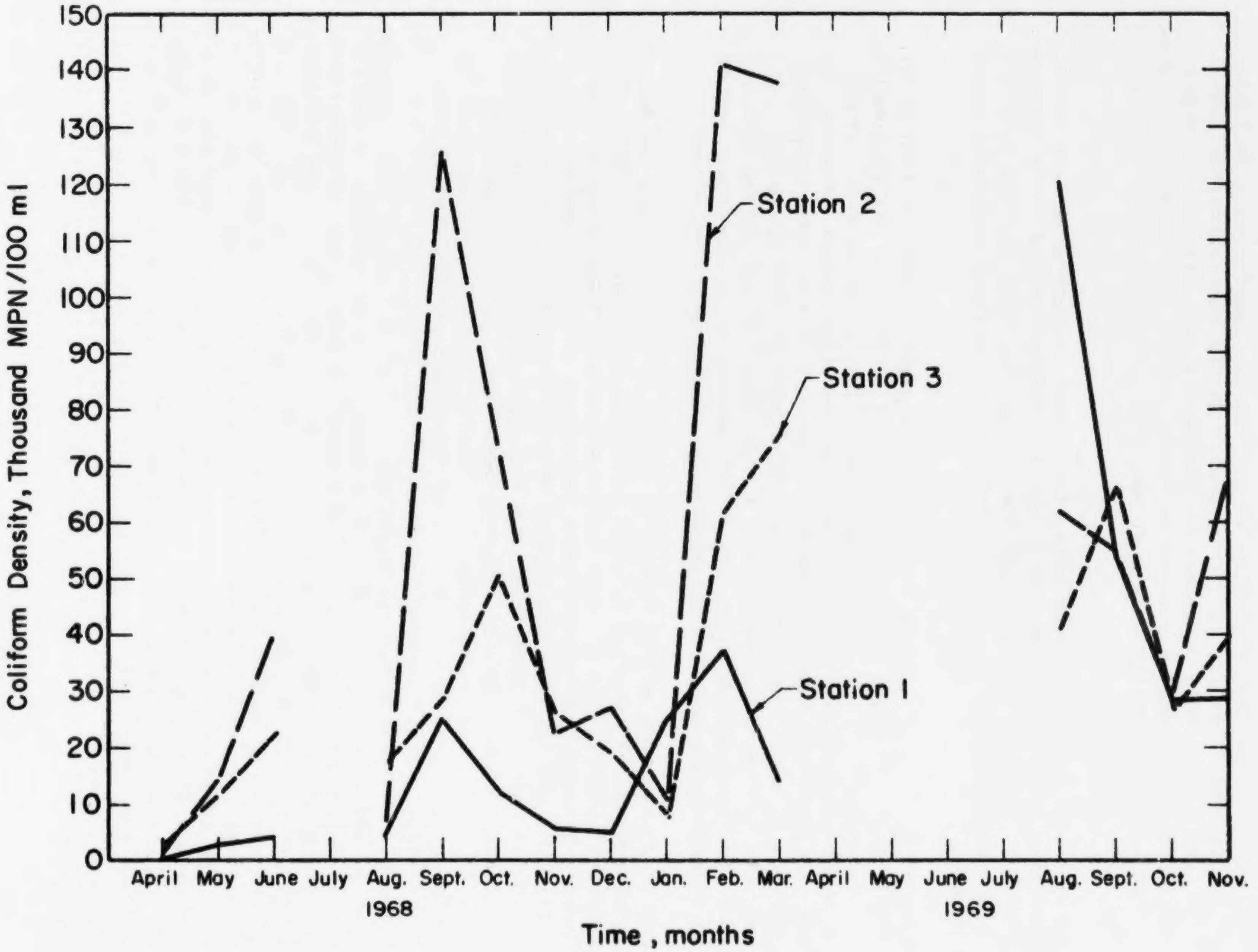


FIGURE 35. Influence of Retention Basin. Discharge on Coliform Density in Receiving Stream

seen that the density of coliforms was considerably increased by the discharge and that decay occurred as the flow passed from Station 2 to Station 3. From the tabulation of correlation coefficients in Table II it is apparent that the coliform density at the two downstream stations was more highly dependent on the density of coliforms in the retention basin discharge than on any other factor. Correlation of downstream coliform density with upstream density and water temperature was low.

As with the retention basin data, the number of determinations on fecal coliforms and fecal streptococci was limited and tended to be somewhat erratic. However, the same conclusions as described for the coliform organisms would seem to apply to both fecal coliforms and fecal streptococci.

Special Biological Studies - The original plans called for biological sampling of the basin and of the receiving stream. It was proposed to do bottom sampling and "cage" sampling of the retention basin itself at monthly intervals. It was also proposed to do bottom sampling of the stream at approximately monthly intervals at the three sampling stations at which chemical and bacterial samples were collected. In addition, it was proposed to have a fish assay of the stream done before the study period began and at the conclusion of the study period to determine changes in fish population of the receiving stream.

One study was made of the receiving stream prior to placing the basin in operation. These samples were collected on October 17, 1966. The report of the results of this investigation was prepared by William J. Tucker, biologist of the Illinois Department of Public Health. As a follow up, the Illinois Department of Public Health was to do all the biological sampling other than the fish assay which was to be done by the Illinois Department of Conservation. The fish assay was made July 25, 1966, and is reported in Illinois Department of Conservation, Division of Fisheries, "Inventory of the Fishes of Six River Basins in Illinois, 1966," Special Fisheries Report Number 18, issued February 1967. Unfortunately, no assay was made at the end of the investigation as had been anticipated. The pressure of other duties on the Illinois Department of Public Health biologists also prevented completion of the biological sampling as was originally anticipated. No biological sampling was done on the basin itself. No further biological sampling of the receiving stream, other than the original report previously mentioned was carried out by the Illinois Department of Public Health. With the addition of a biologist to the staff of the Springfield Sanitary District in June of 1969, it was possible to make a limited study of the stream during the summer and fall of 1969 prior to the termination of the investigation.

Description of Sugar Creek - In 1933 a dam was completed approximately three miles upstream from the point of discharge of the retention basin to form Lake Springfield, the municipal water supply reservoir. As a result, the flow in the stream below the dam during much of the dry season of the year tends to be low since most all of the flow above the dam is retained in Lake Springfield. During times when there is discharge from Lake Springfield, flow in the stream tends to be rather erratic inasmuch as the discharge is very periodic.

There is evidence that some wastes are discharged to the stream between the Lake Springfield Dam and the discharge point of the retention basin. These wastes include the filter wash water from the Water Purification Plant of the City of Springfield, overflow from the fly ash ponds of the municipal power plant at Lake Springfield, a small amount of effluent from a sewage oxidation pond serving two small subdivisions, sewage effluent from the Naval Reserve Center treatment works, and the occasional overflow from a part of the combined sewer system of the City of Springfield. The combined sewer overflow would, in all probability, not influence Sugar Creek inasmuch as its discharge point is located a considerable distance up a tributary to the stream; most of the pollutional constituents discharged are probably retained in the tributary stream rather than discharged into Sugar Creek itself. Actually, there was little visual evidence of any pollution of Sugar Creek above the discharge point of the basin other than fly ash from the power plant lagoons. Branches or floating debris, in and along the stream, are coated with these black particles.

Sugar Creek is typical of small central Illinois streams. It tends to be turbid, of medium width, reasonably deep for streams in this area, and with steep banks. The flow during the 1969 sampling period tended to be generally high even though it was the normal dry season.

The turbidity in the stream is believed to be the result of runoff from the extensively cultivated fields near the stream. There is, however, an area immediately adjacent to the stream which is not cultivated and grows quite thick with tall shrubs, brush and trees. The shrubs and brush create good cover for small animals. Numerous rabbit, quail, pheasant, squirrel and raccoon tracks were observed at all of the sampling stations.

The stream valley is generally a flat fertile valley ranging from one-half to two miles wide. At the ends of the valley bottom, the slopes climb somewhat steeply and at Station 3 they tend to be bluffs. The banks of the stream are typical for streams of the area. They are steep and are of soft mud or clay and provide good places for burrowing animals to exist.

During the period July to December, 1969, when biological sampling was extensive, a considerable amount of rain was experienced in the area, and as a result stream flow was much higher than normal. The average rainfall during this period was 3.31 in. per month which was approximately 1.1 in. per month above the average rainfall for this period of the year. This created considerable flooding and, in general, higher water levels than would be normally experienced. Air temperatures averaged 1.8°F below normal during this time, ranging from the average August temperature of 74.0°F to that in November of 39.7°F.

Prior to placing the basin into operation, sewage overflow from the combined sewers of the City of Springfield at this point caused numerous fish kills. Some of these are briefly described in Appendices I and II. The Illinois Department of Conservation report of 1967, previously referenced, lists four major fish kills from July 1961 through May 1964 and indicates that there were more which were not recorded. According to the report, "All of the reported pollution fish kills on Sugar Creek have been caused by domestic sewage from the Springfield Cook Street Pumping Station. These usually occur after a heavy rain." The only observed fish kill to occur during the time of basin operation and the period of the investigation was in July 1968. At this time, the basin was drained to permit repair of the influent sampling line, and a heavy rain on both July 16 and 17 produced such flows to the basin that little detention time was provided; also, the high flow caused a considerable amount of deposited solids in the bottom of the basin to be scoured and discharged to Sugar Creek. This placed an excessive organic load on the stream and was believed to be the cause of the fish kill.

Fish Survey

In the Illinois Department of Conservation's fish survey of 1966, two stations on Sugar Creek were sampled. The principal species of fish collected were green sunfish, yellow bullheads, pirate perch, white suckers, freshwater drum, carp, black bullheads, and flathead catfish. Unfortunately, no subsequent detailed study of the fish population was made. However, during July to December, 1969, a biological study was made by Sanitary District personnel. In making this study, fish were observed to be present throughout the entire reach of the stream which encompassed the sampling location. It was not unusual to see vast schools of shad numbering in the thousands at the discharge point of the retention basin. There were also many carp having an approximate average length of 8 to 10 in. These fish were normally feeding upon the heavy algae growth that was coming over the pond spillway. The fish population in this area normally was so extensive that many of the carp frequently tried to fight their way up the spillway.

Biological Survey

In October 1966, personnel of the Illinois Department of Public Health sampled Sugar Creek both above and below the then proposed site of the retention basin. Samples were collected on only one day. Based on the results of analyzing these samples, this agency concluded that the stream had an unbalanced biological population and should be classified as polluted.

The only other biological study was carried out by personnel of the Sanitary District during July to December 1969. Rather than collecting bottom samples from the receiving stream, a sampler was devised utilizing plates spaced on a rod that would have exactly 144 sq in. or 1 sq ft of surface area. Eighteen squares of masonite, each 3 in. on a side, were threaded on a rod with one in. squares of masonite for spacers which gave a net surface area on one side of the plates of 145 sq in. or approximately 1 sq ft. This was suspended in the stream from a steel fence post. The masonite was 1/8 in. thick and was spaced with 1/4 in. clear openings between the pieces of masonite and was strung onto a thin aluminum rod which held the sampler to the post. In removing the growth from the plates at the end of the sampling period, the individual pieces of masonite were removed from the rod and one side of each plate was scraped off and utilized as the sample. In this manner the organisms found on the one side represented the number per sq ft.

These samplers proved to be quite successful. They were easier to use than the dredge or the cage type of sampler. They were also much less expensive. There was only one problem with the samplers and that was that vandals frequently removed them from the stream. Eight of these samplers were lost during the test period. For this reason, the samplers were put in fairly deep water so that they would not be visible to anybody normally walking along the stream. However, in spite of the loss of eight of the samplers, the extremely low cost of making them made this a desirable means of conducting sampling.

Sampling of the stream for the special biological studies was done at three stations. These stations generally corresponded to those used for the routine daily chemical sample collection. The first station (No. 1) was 7,000 ft upstream from the discharge point of the retention pond. Station 2 was 5,500 ft downstream and the third station (No. 3) was 14,500 ft downstream from the basin. Each station was subdivided into five substations.

It would seem appropriate to mention that the City of Springfield, several years previously, had ceased municipal collection of garbage. As a result, this stream and others in the area have become unauthorized sites for garbage and trash, particularly at locations where the streams are accessible to the public, i.e. bridges. Because of this condition, the biological sampling points were located upstream from the bridges in all cases.

The 1969 biological survey was carried out using both benthic and lotic samples. Flowing water or lotic samples were obtained at all three stations on July 14, September 2, and October 31, and only at Station 1 on December 16. The benthic samplers, described previously, were placed in the stream originally on July 14 and removed on September 2; the organisms reported as of September 2 were those collected during the period July 14 to September 2. The samplers were replaced on September 2 and removed as of October 31, with the organisms collected during this period being reported as of the later date. Additional samplers were installed on October 31 to be removed on December 16; however, they were either washed away or otherwise disappeared so that it was not possible to obtain additional benthic samples. The detailed results of this study are given in Appendix V.

Since limited biological data are available on Sugar Creek prior to the installation of the retention basin, it is impossible to assess with assurance the value of the basin in eliminating pollution from combined sewer overflow from the Cook Street Pumping Station. In evaluating the 1969 data, it would appear that the receiving stream was moderately polluted with organic matter throughout the reach of study. Further, there appears to be a source of pollution above sampling Station 1. Heavy pollution from sewage was not apparent throughout the length of the stream studied.

Figure 36 gives the results of analyzing the benthic samples collected in 1969 along with the very limited data available as of 1966. At Station 1, above the discharge from the basin, it would appear that there was a change in the biological population between 1966 and 1969. The fact that there appeared to be a shift to more pollution tolerant organisms between the two surveys indicates that more pollution was entering the stream above Station 1 in 1969 than in 1966. The return of more pollution sensitive organisms downstream of the basin discharge (Stations 2 and 3) in 1969 indicates improved stream conditions as compared to the 1966 data. Figure 37 presents the results of examining lotic samples. No data prior to 1969 are available. In considering the 1969 results, it is evident that the biological populations at all three stations consist of both pollution sensitive and tolerant organisms. The presence of pollution was indicated throughout the reach of the stream included in the survey. However, considering the percentage of pollution sensitive organisms, the stream may be judged to have been in fair condition. Contrasting the data for Station 1, above the basin, with those for Stations 2 and 3, below the basin discharge, it would appear that the stream was not being adversely affected to any great extent by the flow from the retention basin.

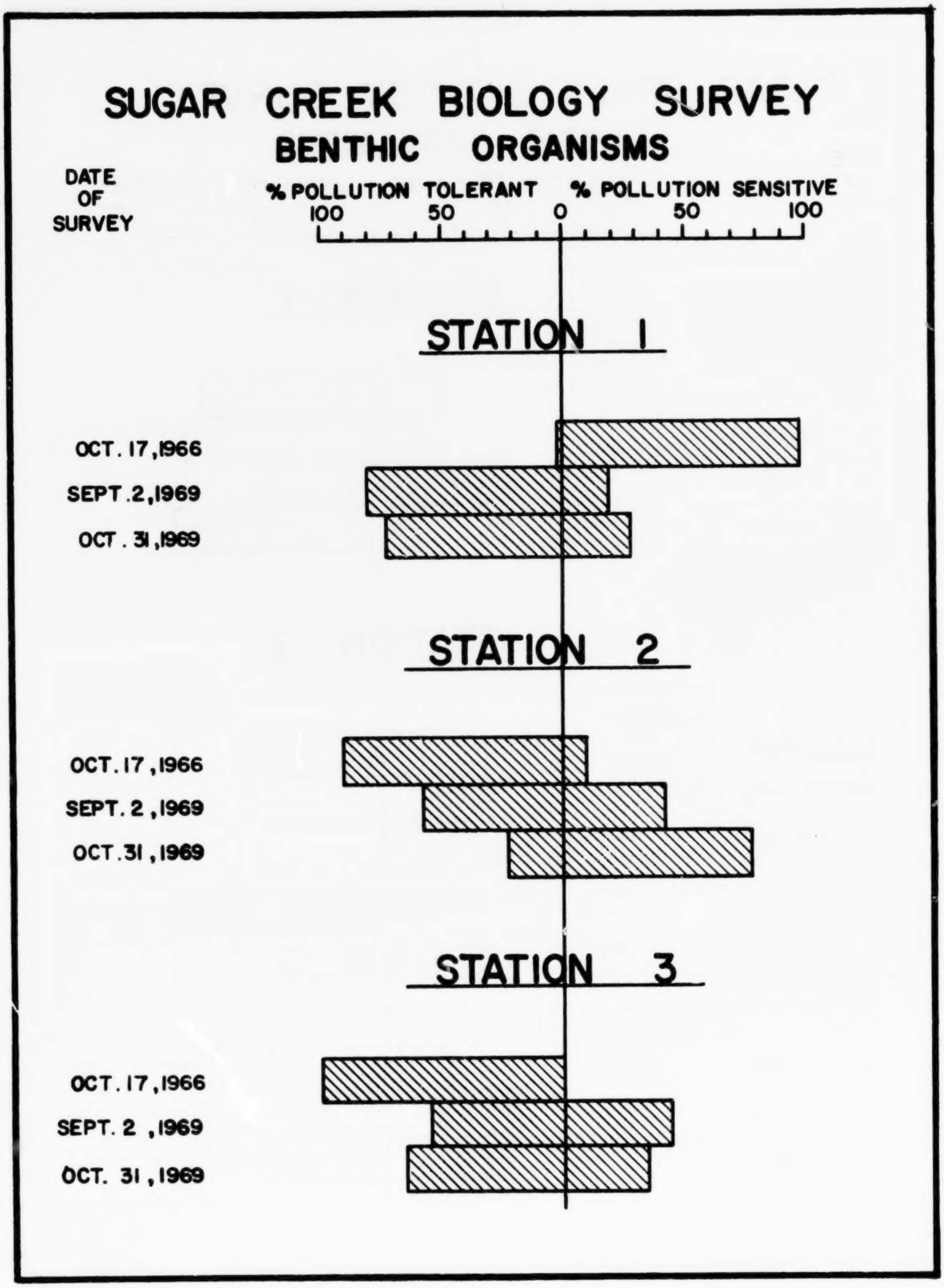


FIGURE 36. Results of Biological Survey of Sugar Creek - Benthic Organisms

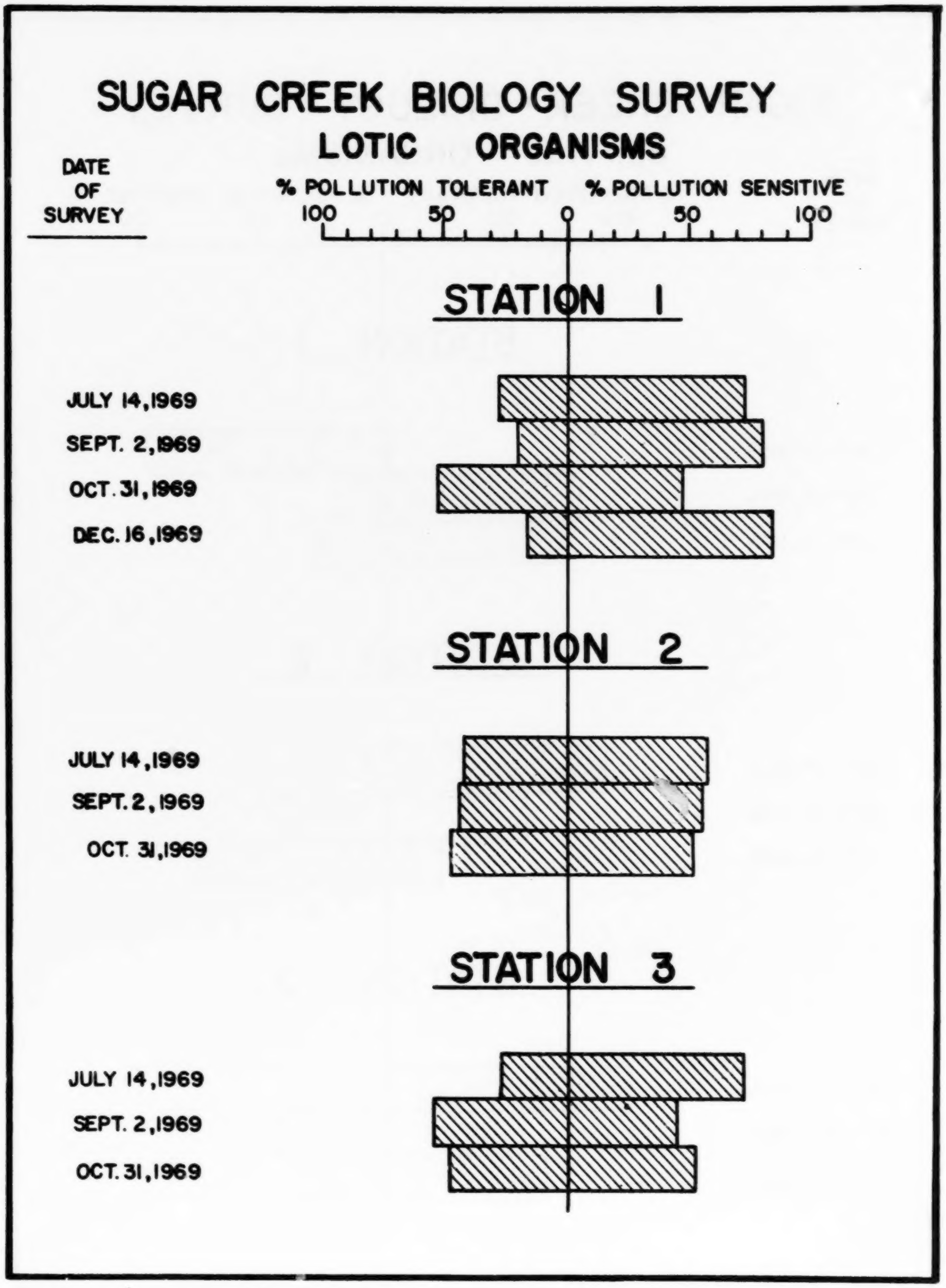


FIGURE 37. Results of Biological Survey of Sugar Creek - Lotic Organisms

SECTION VIII

SUMMARY

Storm overflow from combined sewers discharged through the Cook Street Pumping Station of the Springfield Sanitary District into Sugar Creek has resulted in repeated fish kills during previous years. The present study was undertaken to evaluate the efficacy of a retention basin to prevent such deterioration of water quality. Anticipated possible effects of the basin include attenuation of peak flows, sedimentation, and biological degradation. An anticipated adverse effect of the retention basin was the discharge of algae synthesized in the basin. Performance of the lagoon during the 20 month period of observation indicated that it was successful in preventing severe deterioration of downstream water quality due to combined sewer overflows.

Performance of the lagoon was monitored by daily collection of composite samples from the lagoon influent and effluent and by grab sampling of stations in Sugar Creek above and below the point of lagoon discharge. Interpretation of the capabilities and limitations of the facility was limited by the lack of capability for measuring influent flow rate and the lack of influent and effluent samples collected at various periods during storms. Hence, it was not possible to conduct mass balance computations on the basin to determine its overall effectiveness. Best evidence of the efficiency of the facility was afforded by observation of the fact that incidence of fish kills was limited following installation of the retention basin.

While the movement of individual storm flows through the lagoon could not be traced, it was observed that the average BOD of the effluent was less than that of the influent except during summer and early fall months when production of algae in the basin resulted in effluent BOD values being higher than those of the influent. This observation was substantiated by the increase in suspended solids in the effluent during these periods, increased effluent pH and supersaturation of dissolved oxygen during periods of high radiant energy. It would appear that the suitability of retention basins of the type used at Springfield should be considered on an individual basis because of the possibility of adverse water quality conditions being created as a result of the release of high concentrations of algae during parts of the year.

Considerable reductions in the concentration of indicator organisms occurred in the retention basin as might be expected. However, the concentration of these organisms in the stream below the point of retention basin discharge was still considerable.

Analysis of results of biological surveys of the stream below the point of basin discharge indicates the significant shift in the nature of the benthic organisms following construction of the lagoon. The organisms are now far more pollution-sensitive than those which existed prior to construction of the basin. Significant numbers of pollution-sensitive organisms were also found in the lotic samples following construction of the basin although no similar samples were available prior to construction of the facility for comparison.

While the analysis of the performance of the basin is limited on a quantitative basis, it has been shown to be an adequate solution for the present problem at Springfield, Illinois. Only one fish kill occurred during the period of study, and it happened during a period when the basin was drained for repair.

It has not been possible to quantitatively determine the relative effect of the various mechanisms which could account for the basin's performance. Sedimentation can reasonably be accredited with some water quality improvement inasmuch as appreciable quantities of sludge accumulated in the basin. However, the contribution of bacteria and algae synthesized in the basin to this sediment is not known. Similarly, the amount of biological degradation of soluble and colloidal organic material has not been established. It is postulated that an appreciable amount of the observed improvement can be attributed to retention of storm flow with slow release at diminished rates to the receiving stream.

Unfortunately, the analysis of basin performance does not provide a rational basis for determining the desirable size of storm water retention facilities at other installations. This is because the available instrumentation did not afford a measure of influent flow rate and because daily composite samples were analyzed and because a portion of high storm water overflows were bypassed and did not enter the retention facility. On the basis of the observed increase in biochemical oxygen demand during summer months it could be anticipated that difficulty might be experienced at certain installations because of deterioration of downstream water quality or because of aesthetic objection to the high algal densities. The desirable size of such facilities clearly depends upon the water quality objective involved. For example, where appreciable reductions in the density of indicator organisms is necessary, retention times in the order of magnitude provided at Springfield would not be sufficient. An additional consideration in determining basin volume is the requirement for storage of the appreciable quantities of solids retained in the basin.

SECTION IX

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SECTION X

APPENDICES

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APPENDIX I

INVESTIGATIONS OF POLLUTION OF SUGAR CREEK PRIOR TO IMPLEMENTATION OF PROJECT

A chronological log of investigations and events related to pollution of Sugar Creek by overflow of sewage from the Cook Street Pumping Station is included here. Data obtained from the stream surveys are included in Appendix II.

December 30, 1954. - Sugar Creek was sampled below point of discharge of Cook Street combined sewer overflow. No record of the cause of the investigation is available.

January 4, 1955. - Same as above.

July 21, 1961. - A fish kill occurred on July 17. Investigators from the Illinois State Sanitary Water Board indicated that the kill was presumably due to a sewage overflow from the combined sewers which had traveled down the Cook Street channel to Sugar Creek. However, stream samples were not collected.

August 21 and 22, 1961. - A fish kill occurred in Sugar Creek as a result of combined sewer overflow. Reasonably complete data were collected by both the Sanitary Water Board and the Springfield Sanitary District.

January 22, 1962. - Action was instituted by the Illinois Sanitary Water Board to collect $222.65 for fish killed by the August 21 and 22, 1961 storm sewer overflow.

July 30 and 31, 1963. - A fish kill was reported on Sugar Creek. Investigation revealed dead fish, distressed fish and evidence of recent sewage bypass down the Cook Street channel. On July 31, it was estimated that 150 to 200 gpm combined sewer overflow was being discharged to the channel. No stream samples were collected.

September 12, 1963. - A fish kill in Sugar Creek was investigated and a number of samples were collected. There had been 0.34 in. of rainfall on September 11 and 0.03 in. on September 12. There had been no rain for the preceding six days and a total of 1.07 in. of rainfall for the previous 20 days.

October 19, 1963. - A fish kill was reported and investigated. No dead fish or distressed fish were noted at the time the stream samples were collected. Prior to this time there had been 0.08 in. of rainfall on October 16, a trace on October 17, 0.05 in. on October 18 and 0.88 in. on October 19. There had been no rainfall for 16 days preceding this period and a total of 0.01 in. of rainfall for the 20 days prior to this period.

May 27, 1964. - A fish kill was reported and investigated. While no sewage was overflowing at the time of the investigation, it was apparent that the fish kill had been caused by sewage overflow. An estimated 3,315 fish were killed on this occasion. There had been 0.18 in. of rainfall on May 26, and a trace of rainfall on May 27. There had been no rainfall for a day prior to this time and a total of 1.37 in. of rainfall during the previous 20 days.

May 28, 1964. - A recheck inspection was made on this date and it was found that several hundred gpm of sewage was overflowing from the combined sewers. No stream samples were collected.

July 27, 1964. - A conference was held between the Board of Trustees of the Springfield Sanitary District and Mr. C. W. Klassen and Mr. R. S. Nelle of the Illinois State Sanitary Water Board regarding the problem of pollution of Sugar Creek and the possibility of correction of it. It was agreed the problem resulted from the combined sewer overflows in this area and that the only possibility of a solution lay in some means of treatment of these overflows.

December 30, 1964. - An investigation was made of Sugar Creek. Records do not indicate that the inspection was prompted by a fish kill. No stream samples were collected; however, visual observations of the stream indicated evidence of long term sewage pollution of Sample Point #2. Gray, stringy growths were evident in the stream.

January 5, 1965. - An investigation indicated bypassing during a dry weather period into Sugar Creek.

January 6, 1965. - An additional investigation indicated 150 to 200 gpm bypassing at this time of no rainfall.

January 7, 1965. - Investigation revealed approximately 500 gpm bypassing at time of no rainfall. At this point the Springfield Sanitary District was advised that sewage was overflowing and investigation revealed that one of the diversion structures was clogged which allowed the sewage to bypass in time of dry weather. This was immediately rectified. The Illinois State Sanitary Water Board by letter, advised the Springfield Sanitary District that they would not allow any further extensions to the sewer system tributary to the Cook Street outlet until the problem of sewer overflows was resolved.

May 26, 1965. - An investigation indicated that between 1500 and 3000 gpm of combined sewage overflow was bypassing. All four pumps at the Cook Street Pumping Station were running and no more sewage could be intercepted. There had been 0.10 in. of rain on May 24 and 0.90 in. on May 26. There had been no rain for the previous five days and a total of 0.64 in. of rainfall during the previous 20 days. No stream samples were collected and there was no indication of any fish kill.

May 28, 1965. - A grant for a demonstration project on retention of storm water overflow was requested from the U.S. Department of Health, Education and Welfare.

May 18, 1966. - An investigation was made by Sanitary Water Board personnel and stream samples were collected. There was no fish kill evident on this occasion. There had been 1.35 in. of rain on May 17. There had been one day prior to this time with no rainfall and a total of 1.38 in. of rain had fallen during the preceding 20 days.

July 28, 1965. - Stream samples were collected by Sanitary District personnel. There had been 0.67 in. of rainfall on July 27. There had been no rain for the preceding eight days and a total of 0.28 in. of rain during the previous 20 days.

July 29, 1966. - Stream samples were again collected by Sanitary District personnel. The samples indicated a reasonably good recovery of the stream following the unsatisfactory conditions observed on the previous day.

August 10, 1966. - Stream samples were collected by Sanitary District personnel. There had been 0.13 in. of rain on August 8, 0.08 in. on August 9, and 0.85 in. on August 10. There had been no rainfall for six days preceding this period and a total of 1.04 in. of rainfall during the previous 20 days.

APPENDIX II

DATA FROM WATER QUALITY SURVEYS PRIOR TO IMPLEMENTATION OF PROJECT

Sample Point #1 - Route 29 Bridge
7000 ft Above Discharge Point

Date	pH	DO (mg/l)	BOD (mg/l)	Coliforms (no./100 ml)	Enterococcus (no./100 ml)	Observations
8/21/61	7.6	-	2.6	2000	80	Stream normal(1)
8/22/61	8.3	5.8	4.0	-	-	No evidence of pollution(1)
9/12/63	7.1	5.8	2.0	-	-	70 mg/l suspended solids, 14% volatile
5/18/66	-	9.0	3.0	-	-	Stream normal
7/28/66	-	5.2	0.8	-	-	Stream normal(2)
7/29/66	-	6.0	1.0	-	-	Stream normal(2)
8/10/66	-	6.1	2.7	-	-	Turbid(2)

Sample Point #2 - Mechanicsburg Bridge
5500 ft Below Discharge Point

Date	pH	DO (mg/l)	BOD (mg/l)	Coliforms (no./100 ml)	Enterococcus (no./100 ml)	Observations
12/30/54	-	8.4	8.2	-	-	-
1/4/55	-	4.2	24.0	-	-	-
8/21-22/61	7.5	-	13.0	1,000,000	2,000	No dead fish(1)
8/22/61	7.6	2.7	8.1	-	-	No dead fish(1)
9/12/63	7.1	5.4	1.5	-	-	Creek gray - 30 mg/l suspended solids, 33% volatile
10/19/63	-	3.9	-	-	-	Turbid
5/18/66	-	7.7	7.0	170,000	1,100	No dead fish
7/28/66	-	3.8	3.0	-	-	2 dead fish(2)
7/29/66	-	6.5	2.0	-	-	Stream normal(2)
8/10/66	-	2.0	29.4	-	-	Turbid, no dead fish(2)

Sample Point #3 - Oak Lane Bridge
14,500 ft Below Discharge Point

Date	pH	DO (mg/l)	BOD (mg/l)	Coliforms (no./100 ml)	Enterococcus (no./100 ml)	Observations
5/15/59	-	1.7	-	-	-	Fish kill reported-no dead fish noted
5/15/59	-	2.4	-	-	-	Fish kill reported-no dead fish noted
8/21-22/61	7.4	-	8.0	620,000	790	282 dead fish counted(1)
8/22/61	7.6	2.3	6.7	-	-	30 dead fish counted upstream from point of discharge
9/12/63	6.9	0	4.0	-	-	Sewage odor & discoloration; some fish in distress; 290 mg/l suspended solids; 3% volatile
10/19/63	6.7	0.4	20.0	-	-	Turbid, no fish killed
5/27/64	-	0	-	1,200	580	Estimated 3,315 fish killed
5/18/66	-	7.1	7.7	190,000	1,800	No dead fish
7/28/66	-	0	7.9	-	-	No dead fish(2)
7/29/66	-	5.3	5.7	-	-	Stream normal(2)
8/10/66	-	5.3	2.8	-	-	Turbid(2)

Other Stream Samples

Date	pH	DO (mg/l)	BOD (mg/l)	Coliforms (no./100 ml)	Enterococcus (no./100 ml)	Location
8/21-22/61	7.5	-	28	3,200,000	45,000	Sugar Creek - 150 ft downstream from Cook Street channel outlet
10/19/63	7.2	3.0	-	-	-	Sangamon River - Coal Bank Bridge

Cook Street Channel Samples

Date	pH	DO (mg/l)	BOD (mg/l)	Coliforms (no./100 ml)	Enterococcus (no./100 ml)	Location
8/21-22/61	7.3	-	54	15,000,000	80,000	Evidence of sewage - channel septic
8/21-22/61	7.4	-	15	3,200,000	75,000	Sample taken at U.S. By-pass #66
9/12/63	7.1	4.6	11	-	-	Sewage evident, septic, sludge worms, 30 mg/l suspended solids, 33% volatile
5/18/66	-	6.1	>4	-	-	Evidence of sewage

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(1) Data collected by Illinois State Sanitary Water Board

(2) Data collected by Springfield Sanitary District

APPENDIX III

DATA SHEET FOR RETENTION BASIN STUDIES

SPRINGFIELD SANITARY DISTRICT

COOK STREET STORM WATER OXIDATION POND

MONTHLY LOG OF POND DATA

__________, 19__

Prepared By __________

Date	Weather Conditions						Pond Conditions			Influent Quality											Effluent Quality								
	Ave. Air Temp.	Rain-fall	Possible Sunshine	Wind Speed	Wind Direction	Evaporation	Water Surface Elev.	Outflow Rate	Inflow Rate	B.O.D.	Susp Solids	Volatile S.S.	Dis. Oxy.	Temp.	M.B.A.S.	pH	Coliform Density	Fecal Colif's	Fecal Strep.		B.O.D	Susp Solids	Volatile S.S.	Dis. Oxy.	Temp.	pH	Coliform Density	Fecal Colif's	Fecal Strep.
	°F	in./day	%	m.p.h.		in.	Ft.	m.g.d.	m.g.d.	mg./l.	mg./l	%	mg./l.	°F	mg./l.		Number per 100 ml.				mg./l	mg./l	%	mg./l.	°F		Number per 100 ml		
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APPENDIX IV

DATA SHEET FOR SUGAR CREEK STUDIES

SPRINGFIELD SANITARY DISTRICT

COOK STREET STORM WATER OXIDATION POND

MONTHLY LOG OF STREAM DATA

________________, 19___

Prepared By ________________

Date	Streamflow		Station 1 — 7000 Ft. Upstream									Station 2 — 5500 Ft. Downstream									Station 3 — 14,500 Ft. Downstream								
	Lake Spfld. Elev. Ft.	Est. Stream-flow	B.O.D. mg./l.	Susp. Solids mg./l.	Volatile S.S. %	Dis. Oxy. mg./l.	pH	Coliform Density Number per 100 ml.	Fecal Coli's	Fecal Strep.	Temp. °F	B.O.D. mg./l.	Susp. Solids mg./l.	Volatile S.S. %	Dis. Oxy. mg./l.	pH	Coliform Density Number per 100 ml.	Fecal Colifs	Fecal Strep.	Temp. °F	B.O.D. mg./l.	Susp. Solids mg./l.	Volatile S.S. %	Dis. Oxy. mg./l.	pH	Coliform Density Number per 100 ml.	Fecal Colif's	Fecal Strep.	Temp. °F
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APPENDIX V

RESULTS OF BIOLOGICAL SURVEYS OF SUGAR CREEK

Biological Data — Date: July 14, 1969
Station Number: 1-a, b, c, d & e

Sample Site: Stream 1
Stream Condition: Just below flood stage but receding
Water Temperature: 81°F
Bacterial Counts: Total, 450,000/100 ml; Fecal coliforms, 30,000/100 ml
Flow Rate of Water (approx.): Swift

Benthic Samples
No benthic samples - placed samplers in on this date

Lotic Samples - Organisms found
- Sewage algae (*Fusarium aqueductum*)
- Mayfly eggs (*Baetis spp.*)
- Leeches (*Hirudinea spp.*)
- Snails (*Gastropoda*)
- Mayflies (*Baetis spp.*)
- Crayfish (*Cambarus diogenes*)
- Sowbugs (*Asellus commumis*)
- Water flea (*Cyclops spp.*)
- Fairy shrimp (*Eubranchipus vernalis*)
- Planaria (*Planaria maculata*)
- Toad (*Bufo americanus*)
- Mudpuppy (*Necturus spp.*)

Biological Data — Date: July 14, 1969
Station Number: 2-a, b, c, d & e

Sample Site: Stream 2
Stream Condition: High, muddy
Water Temperature: 80°F
Bacterial Counts: Total, 180,000/100 ml; Fecal coliforms, 27,000/100 ml
Water Flow: Swift

Benthic Samples
No benthic samples

Lotic Samples - Organisms found
- Sewage algae (*Fusarium spp.*)
- Mayfly nymphs (*Ephemera*)
- Frog tadpole (*spp. unknown*)

Darter (Boleosoma spp.)
Minnow (Hyporhynchus spp.)
Blackfly (Simulium spp.)
Midge (Chironomus spp.)
Copepod (Diaptomus spp.)
Water flea (Cyclops)
Water flea (Daphnia)

Biological Data — Date: July 14, 1969
Station Number: 3-a, b, c, d & e

Sample Site: Stream 3
Stream condition: High, high turbidity
Water Temperature: 80°F
Bacterial Counts: Total, 130,000/100 ml; Fecal coliforms, 9,000/100 ml
Flow Rate of Water: Swift

Benthic Samples
No benthic samples

Lotic Samples - Organisms found
Crayfish (Cambarus diogenes)
Sowbugs (Asellus communis)
Dragonfly nymph (Anax spp.)
Stonefly nymph (Perla spp.)
Watermites (hydrachna spp.)
Perch (Percaflauesceus)
Shiner (Notropis spp.)
Midge or punky (Culicoides)
Scenedesmus
Oocystis
Ankistrodesmus

Biological Data — Date: September 2, 1969
Station Number: 1-a, b, c, d & e

Sample Site: Stream 1
Stream Condition: Very low
Water Temperature: 78°F
Bacterial Counts: Total, 580,000/100 ml; Fecal coliforms, 27,000/100 ml
Flow Rate of Water (approx.): 3 cfs

Benthic Samples
Tubifex tubifex
Caddisfly house
Carchesium

Lotic Samples - Organisms found

- *Oscillatoria*
- *Ulothrix*
- *Euglena viridis*
- Crayfish (*Cambarus diogenes*)
- Sewage worm (*Tubifex tubifex*)
- *Vorticella*
- Carp (*Cyprinus carpio*)
- Perch (*Perca flavescens*)

Biological Data

Date: September 2, 1969
Station Number: 2-a, b, c, d & e

Sample Site: Stream 2
Stream Condition: Low
Water Temperature: 70°F
Bacterial Counts: Total, 430,000/100 ml; Fecal coliforms 57,000/100 ml
Flow Rate of Water (approx.): 4.5 cfs

Benthic Samples

- Caddis fly larva (*Chimarra*)
- Mayfly nymphs (*Heptagenia*)
- Mayfly nymphs (*Ephemerella*)
- Snail (*Gyraulus*)
- Clam (*Pisidium*)
- Rotifers (*Rotifera*)
- Sewage worm (*Tubifex*)
- Hydra (*Hydra*)
- Crayfish (*Cambarus*)

Lotic Samples

- Copepods (*Diaptomus*)
  (*Cyclops*)
- Eurycerus (*Eurycerus*)
- Daphnia (*Daphnia*)
- Crayfish (*Cambarus*)
- Protozoans (*Paramecium*)
  (*Amoeba*)
- Chlamydomonas (*Chlamydomonas*)
- Desmid (*Closterium*)

Biological Data

Date: September 2, 1969
Station Number: 3-a, b, c, d & e

Sample Site: Stream 3
Stream Condition: Low, clear
Water Temperature: 78°F
Bacterial Counts: Total, 400,000/100 ml; Fecal coliforms 30,000/100 ml

Flow Rate of Water: 1.9 cfs

Benthic Samples
Crayfish (*Cambarus*)
Caddisfly *house* (unidentified)
Tubifex(*Tubifex*)
Water scavenger (*Hydrophiluc*)
Hydra (*Hydra oligactis* [fusca])
Vorticella (*Vorticella campanula*)
Sphaerium clam corneum
Carchesium polypinum

Lotic Samples - Organisms found
Catfish (*Ictalurus*)
Mosquitofish (*Gambusia*)
Carp (*Carpoides*)
Algae (*Crucigenia tetrapedia*)
(*Synura uvella*)
(*Scenedesmus spp.*)
Snake (*Natrix sipedon* subspecies sipedon)

Biological Data — Date: October 31, 1969
Station Number: 1-a, b, c, d & e

Sample Site: Stream 1
Stream Condition: Fairly low, more than normal fly ash
Water Temperature: 51°F
Bacterial Counts: Total, 100,000/100 ml; Fecal coliforms, 9,000/100 ml
Flow Rate of Water: 5 cfs

Benthic Samples
Tubifex tubifex
Crayfish (*Cambarus*)
Nematode worm eggs
Bryozoan (*Plumatella*)
Snake burrow

Lotic Sample - Organisms found
Blue-green Algae (*Rivularia*)
(*Nostoc*)
(*Oscillatoria*)
Green Algae (*Ankistrodesmus*)
(*Richterella*)
Bluegill (*Lepomis macrochirus*)

Biological Data — Date: October 31, 1969
Station Number: 2-a, b & c

Sample Site: Stream 2

Stream Condition: Higher than normal
Water Temperature: 51°F
Bacterial Counts: Total, 25,000/100 ml; Fecal coliforms, 700/100 ml
Flow Rate of Water: 5.2 cfs

Benthic Samples
No benthic samples

Lotic Samples - Organisms found
Tubifex (*Tubifex*)
Euglena (*Euglena viridis*)
Paramecium (*Paramecium spp*.)
Phacus (*Phacus*)
Amoeba (*Amoeba*)
Carchesium
Ankistrodesmus
Crucigenia
Ulothrix

Biological Data
Date: October 31, 1969
Station Number: 3-a, b, c, d & e

Sample Site: Stream 3
Stream Condition: Fairly high
Water Temperature: 51°F
Bacterial Counts: Total, 50,000/100 ml; Fecal coliforms, 4,500/100 ml
Flow Rate of Water: 4.7 cfs

Benthic Samples
Hydra (*Hydra spp*.)
Stentor (*Stentor spp*.)
Vorticella
Planaria
Leech (*Hirudinea*)
Tubifex

Lotic Samples - Organisms found
Euglena (*Euglena viridis*)
Phacus
Spirogyra
Kirchneriella
Desmid (*Straurastrum*)
Ankistrodesmus

Biological Data
Date: December 16, 1969
Station Number: 1-a, b, c, d & e

Sample Site: Stream 1

Stream Condition: Normal level
Water Temperature: 33°F
Bacterial Counts: Total, 30,000/100 ml; Fecal coliforms 1,000/100 ml
Flow Rate of Water: 3 cfs

Benthic Samples

No benthic samples

Lotic Samples - Organisms found

- Earthworm (*Lumbriculus variegata*)
- Cyclops (*Cyclops strenuus*)
- Leech (*Hirudinea spp.*)
- Protozoa (*Carchesium*)
  - (*Vorticella*)
  - (*Stentor*)
  - (*Paramecium*)

1 Accession Number **W**	2 Subject Field & Group	**SELECTED WATER RESOURCES ABSTRACTS** **INPUT TRANSACTION FORM**

5 *Organization*

Springfield Sanitary District, Springfield, Illinois

6 *Title*

Retention Basin Control of Combined Sewer Overflows,

10 *Author(s)*

16 *Project Designation*

FWQA, Department of Interior, Grant 3-111-1

21 *Note*

22 *Citation*

Report, Water Pollution Control Research Series, 11023---08/70, 1970, 97 p.

23 *Descriptors (Starred First)*

*Combined sewers, Urban drainage, Retention basins, Lagoons, Combined sewer overflow

25 *Identifiers (Starred First)*

27 *Abstract*

Control of combined sewer overflows by retention in an open basin has been evaluated. Fish kills, which were numerous prior to construction of the facility, ceased and there was an increase in the abundance of pollution sensitive organisms in the stream below the basin.

Average annual reduction of BOD was 27 percent and coliform reduction averaged 72 percent. However during the period from June through October 1969, production of algae in the basin caused the effluent BOD to consistently exceed that of the influent. In addition to the oxygen demand on the stream, production of algae may be objectionable at some installations for aesthetic reasons. Sludge accumulation was significant in the basin and must be taken into account in design of similar facilities. Suggestions for future designs of retention basins are included.

Abstractor	*Institution*

WR:102 (REV. JULY 1969)
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11023 --- 09/67	Demonstrate Feasibility of the Use of Ultrasonic Filtration in Treating the Overflows from Combined and/or Storm Sewers
11020 --- 12/67	Problems of Combined Sewer Facilities and Overflows, 1967, (WP-20-11)
11023 --- 05/68	Feasibility of a Stabilization-Retention Basin in Lake Erie at Cleveland, Ohio
11031 --- 08/68	The Beneficial Use of Storm Water
11030 DNS 01/69	Water Pollution Aspects of Urban Runoff, (WP-20-15)
11020 DIH 06/69	Improved Sealants for Infiltration Control, (WP-20-18)
11020 DES 06/69	Selected Urban Storm Water Runoff Abstracts, (WP-20-21)
11020 --- 06/69	Sewer Infiltration Reduction by Zone Pumping, (DAST-9)
11020 EXV 07/69	Strainer/Filter Treatment of Combined Sewer Overflows, (WP-20-16)
11020 DIG 08/69	Polymers for Sewer Flow Control, (WP-20-22)
11023 DPI 08/69	Rapid-Flow Filter for Sewer Overflows
11020 DGZ 10/69	Design of a Combined Sewer Fluidic Regulator, (DAST-13)
11020 EKO 10/69	Combined Sewer Separation Using Pressure Sewers, (ORD-4)
11020 --- 10/69	Crazed Resin Filtration of Combined Sewer Overflows, (DAST-4)
11024 FKN 11/69	Storm Pollution and Abatement from Combined Sewer Overflows-Bucyrus, Ohio, (DAST-32)
11020 DWF 12/69	Control of Pollution by Underwater Storage